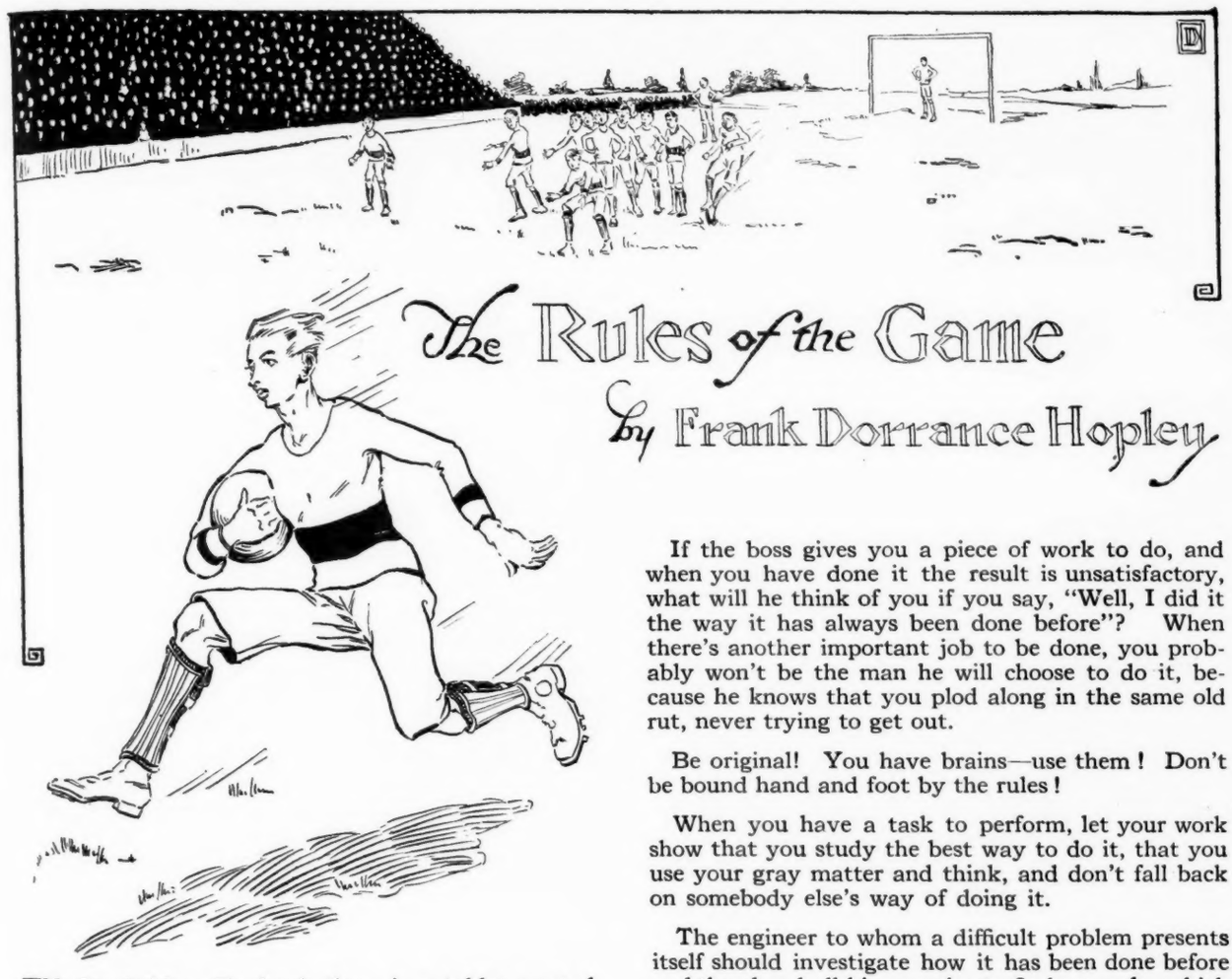
POWER

Volume 49 New York, June 3, 1919 *Number* 22



The Rules of the Game

By Frank Dorrance Hopley

IN Cambridge, England, there is a tablet erected in memory of a man who, when playing a game of football, took the ball and ran down the field with it. By doing this he broke the rules of the game but he invented the game of Rugby, which has since become famous.

This incident only goes to show that the fellow who does things "according to Hoyle" is not always the man who "gets there." Persistently following rule of thumb is likely to lead a man up a blind alley.

The engineer, the mechanic or the workman who does a thing in a certain manner because it has always been done that way in the past is losing the opportunity for self-advancement and new power.

Initiative is a long word, but it means working out your own ideas in your own way and not according to the rules laid down by someone else.

If the boss gives you a piece of work to do, and when you have done it the result is unsatisfactory, what will he think of you if you say, "Well, I did it the way it has always been done before"? When there's another important job to be done, you probably won't be the man he will choose to do it, because he knows that you plod along in the same old rut, never trying to get out.

Be original! You have brains—use them! Don't be bound hand and foot by the rules!

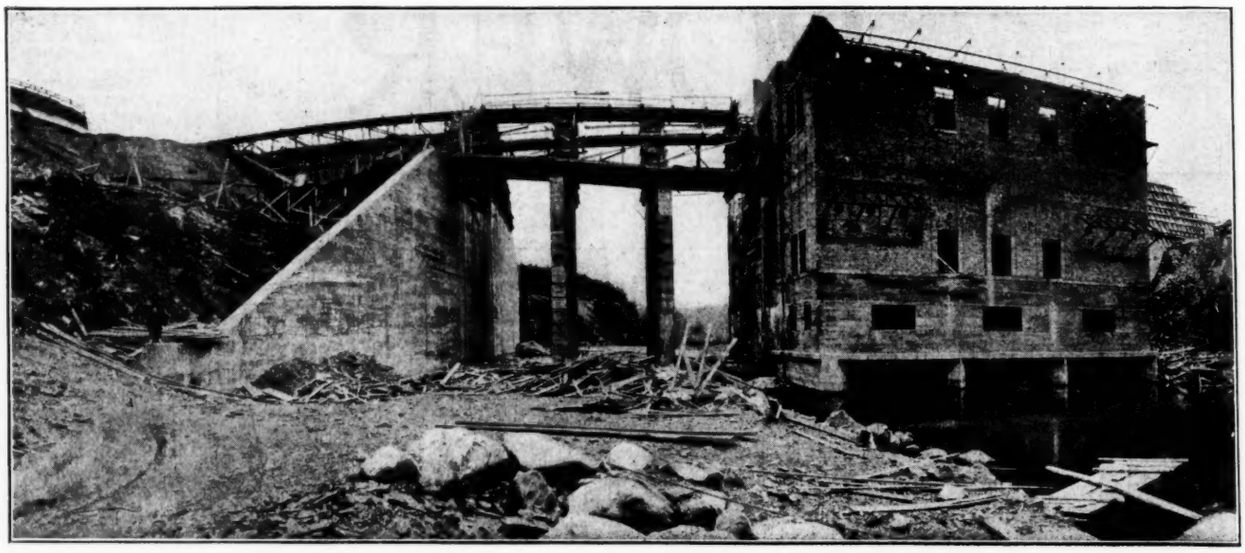
When you have a task to perform, let your work show that you study the best way to do it, that you use your gray matter and think, and don't fall back on somebody else's way of doing it.

The engineer to whom a difficult problem presents itself should investigate how it has been done before and then bend all his energies to find a way by which it can be done better. The man who does that is the man who one day finds himself at the very top of the ladder.

Just remember the fellow who grabbed the ball and ran with it down the football field. He broke the rules of the game but he made himself famous.

Fame may not come to you. In all probability there will be no tablet raised to your memory. But if you use your head and show that you know how to plan your work, always looking for a new and better way to do the thing you have to do, there will be a whole lot more money in your pocket at the end of the year, which in these days is much to be desired.

Break the rules of the game once in a while and see what happens. You will not be disappointed.



Brule River Hydro-Electric Development

By C. V. SEASTONE*

Outline of Peninsular Power Co. system with detailed description of latest hydraulic development on the Brule River. A three-unit modern plant generating three-phase 60-cycle current at 6600 volts. Vertical shaft turbines operate under a head approximating 60 feet.

THE Peninsular Power Co. is completing a hydro-electric development on the Brule River at a location about three miles from Florence, Wis. The construction of this plant was begun in June, 1917, and efforts are being made to finish it early in 1919.

Below Florence the Michigamme River flows into the Brule and the two streams unite to make the Menominee River. Early in 1913 the Peninsular Power Co. completed its first hydro-electric development on the Menominee River at a point commonly known as Twin Falls, near Iron Mountain, Mich. This plant has a machine capacity of about 5500 kw. The company also has a 3500-kw. auxiliary steam plant at its principal substation at Iron River, Mich. A 66,000-volt transmission line connects the Twin Falls plant and the substation at Iron River, Mich. The Brule River plant will be connected to the main transmission system, requiring about three miles of line. The company furnishes electrical power to the iron mines in the vicinity of Florence, Wis., Iron Mountain and Iron River, Mich., and to various villages and towns in that vicinity.

According to the general layout of the proposed hydro-electric development the Brule River is divided at this location by an island that is approximately 1000 ft. long. In the south channel between the island and the Wisconsin shore are the power house and the main concrete dam, the latter being flanked on the Wisconsin side by a concrete abutment and earthen section. Flood discharge is provided for by the installation of eight tainter gates, each 12 ft. high and 14 ft. long. These gates are constructed on the island and discharge into the north channel, which is independent from the discharge from the power house.

In the north channel is to be constructed an earthen dam provided with a concrete corewall. All the construction work is founded upon solid rock with the exception of a length of about 70 ft. of the corewall in the center of the north channel. Evidently the north channel was the original bed of the stream. Excavation to a depth of about 18 ft. below the bottom of the river revealed a solid bed of boulders of varying sizes up to several cubic feet each. It was not considered essential to carry the excavation to solid rock in this section as it is believed from the character of the material encountered that the seepage will be nominal. The average working head provided by the dam is 60 feet.

The cross-section of the concrete dam between the power house and the abutment on the Wisconsin shore is about 70 ft. long and supports piers on the downstream side on which is constructed a concrete roadway to the power house. Under-drainage is provided by a 12-in. vitrified-tile drain placed longitudinally with the dam, as indicated, and connecting with 12-in. lateral drains at right angles to the collecting drain.

To determine the effect of upward pressure under the dam, if any exists, 1-in. iron pipes have been placed as indicated on the drawing. Their upper ends at the rock surface terminate in sheet-iron funnels 12 in. diameter, care being taken during construction to see that no concrete was placed under the funnel. A line of pipes of similar character and arrangement was also placed under the power house. It is believed that after the construction is completed and the head raised, the above may afford some opportunity for observing the extent of the upward pressure and thus furnish information that may be of some value.

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Fig. 3 is a cross-section of the tainter gate spillway. Six of the gates are provided with hand hoists so designed as to later admit of electrical operation, and two of the gates have electric hoists. A concrete counterweight as shown is provided to reduce the force required to lift the gates.

The earthen section in the north channel is provided with a concrete corewall 5 ft. thick at the stream bed and 2 ft. thick at the top. This corewall is well anchored to rock walls on both ends and is founded on rock except a section of about 70 ft. in the center of the channel. The earthen section has a 3 to 1 slope on the upstream side and a 2 to 1 slope on the downstream side. The upstream side to a point about 20 ft. below the normal water surface will be riprapped with stone.

sisting of one 56-in. vertical-shaft Leffel turbine, furnished with shaft extension for direct connection to a vertical-shaft generator, governor, oil-pressure pump, piping and valves. When operating under a head of 60 ft., each turbine will develop 3100 hp. at 240 revolutions per minute. The turbines are installed in concrete scroll cases and are mounted on concrete curved draft tubes. The turbines are guaranteed to give the following efficiencies:

Per cent. power	100	95	90	80	70	60	50
Per cent. effic.	80.9	87.6	88.5	87.4	84	81.4	78.7

For regulating the speed of the turbines, Woodward 21,000-ft.-lb. oil-pressure relay-valve governors are installed.

The generators are 2000-kv.-a. three-phase 60-cycle

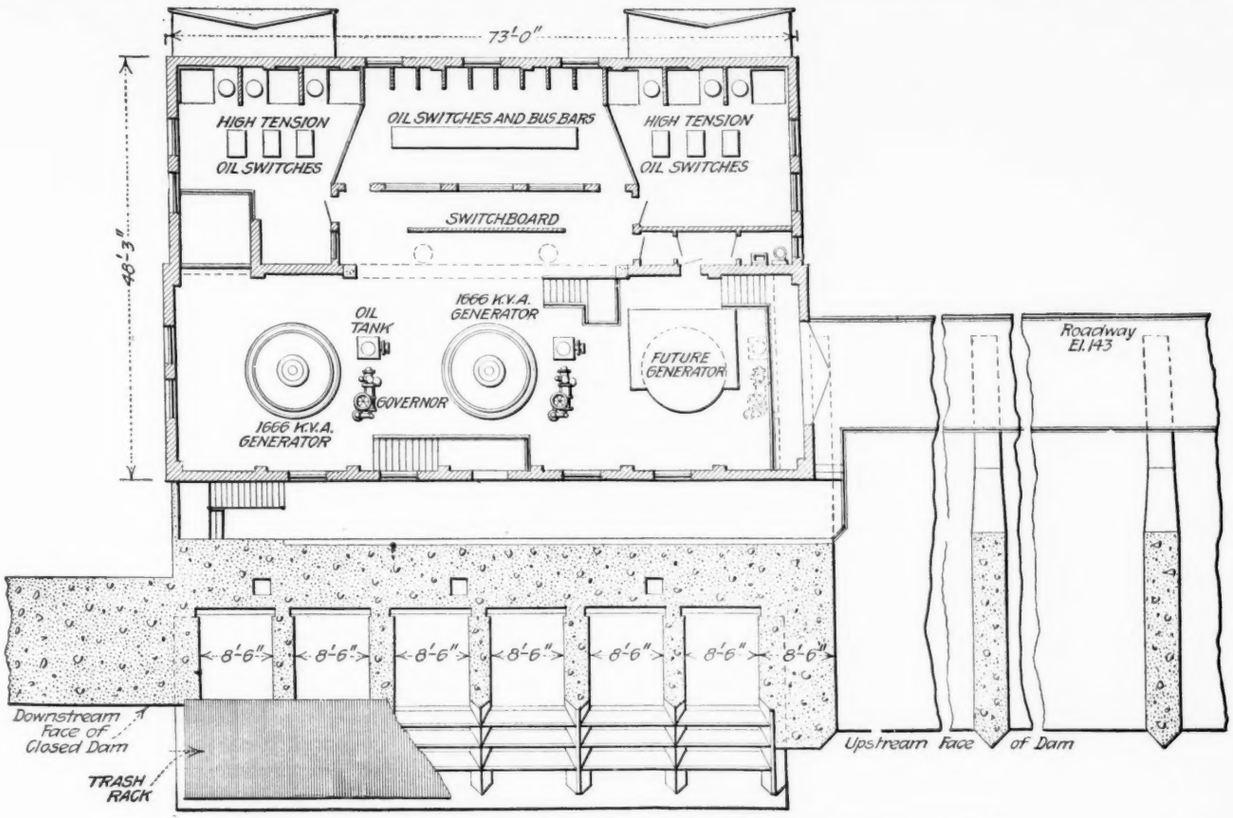

FIG. 1. PLAN VIEW OF THE POWER HOUSE, GIVING CHIEF DIMENSIONS

An upstream view of the power house is shown in the headpiece and Fig. 2 is a cross-section through the plant. The foundations, wheel pits and forebay are of concrete construction, and the superstructure is of common brick laid in a chocolate-colored mortar. The switchboard is on the same floor level with the generators and the transformers are on the floor below.

Fig. 1 is a sectional plan at the generator-room floor level. As the transformers are below this level, an opening is provided which permits of raising them to the main floor, and a suitable chain hoist is provided for this purpose. The cross-section, Fig. 2, shows the location of the pipes that have been placed for observing the extent of the upward pressure. The penstock gates, of which there are two for each unit, are operated by electrically driven geared hoists.

Although completed for the installation of three units, the power house at present has two machines, each con-

6600-volt vertical Westinghouse machines, each provided with two guide bearings and a Kingsbury thrust bearing. A 60-kw. 125-volt shunt-wound direct-connected exciter, designed for operation with a Tyrill regulator, serves each generator.

There are four 1667-kv.-a. single-phase 66,000-6600-volt transformers provided, one constituting a spare unit. These transformers are equipped with copper cooling coils and three are mounted upon a suitable track. The spare unit has been placed upon a truck to facilitate moving to place.

The switchboard, of Westinghouse design, is centrally located on the same floor elevation as the generators and low-tension busbars. It consists of nine panels of natural black slate and one swinging bracket, as follows: One low-tension station lighting panel, one low-tension station power panel, a direct-current emergency control unit panel, an exciter panel, three generator

panels and two feeder panels. On the swinging bracket are mounted the synchronoscope, frequency meter, direct-current voltmeter, alternating-current voltmeter and alternating-current ammeter. The main control rheostat is mounted on pipe framework above and back of the board proper. All but the future generator panel are furnished with the necessary control lights, switches, meters, voltmeter receptacles and relays.

The location of the switchboard is such that the operator, standing at either end of the board, can see the three generators, the six high-tension oil switches, the low-tension oil switches, busbars and instrument compartments. By this arrangement a flashover in any part of the building on this floor can be located immediately and repairs made quickly.

A single-line diagram of the electrical connections is shown in Fig. 4. Either or both generators may be used to supply the demand, and disconnecting switches permit cutting out of service any of the feeder circuits.

The control wires are carried in metal conduits from the low-tension busbar, instrument compartments and machines. The system is ordinarily operated by 110-volt current from the exciter bus, but provision has been made for emergency control and lighting by the installation of a 10-hp. turbine direct-connected to a 9-kw. 125-volt generator. In connection with this unit a separate or emergency system of lighting has been installed throughout the building, so that all possible haste may be made in repairing damaged equipment or replacing equipment destroyed by lightning or otherwise.

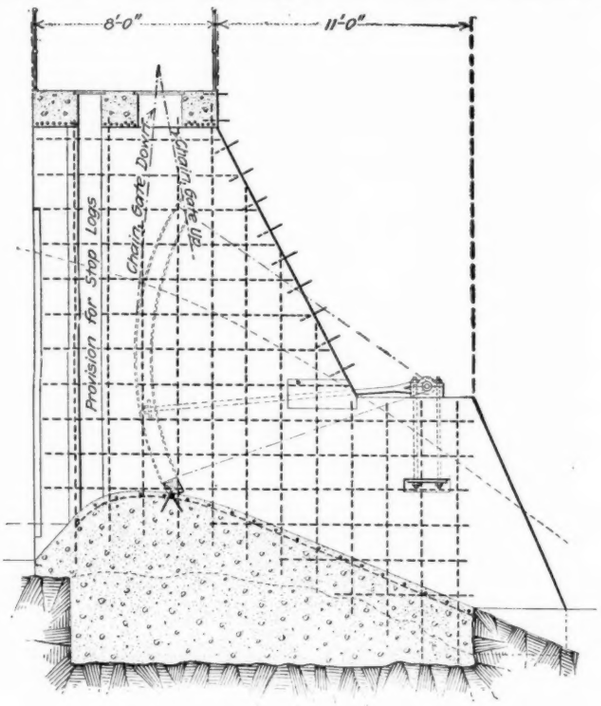

FIG. 3. SECTION TAINTER GATE SPILLWAY

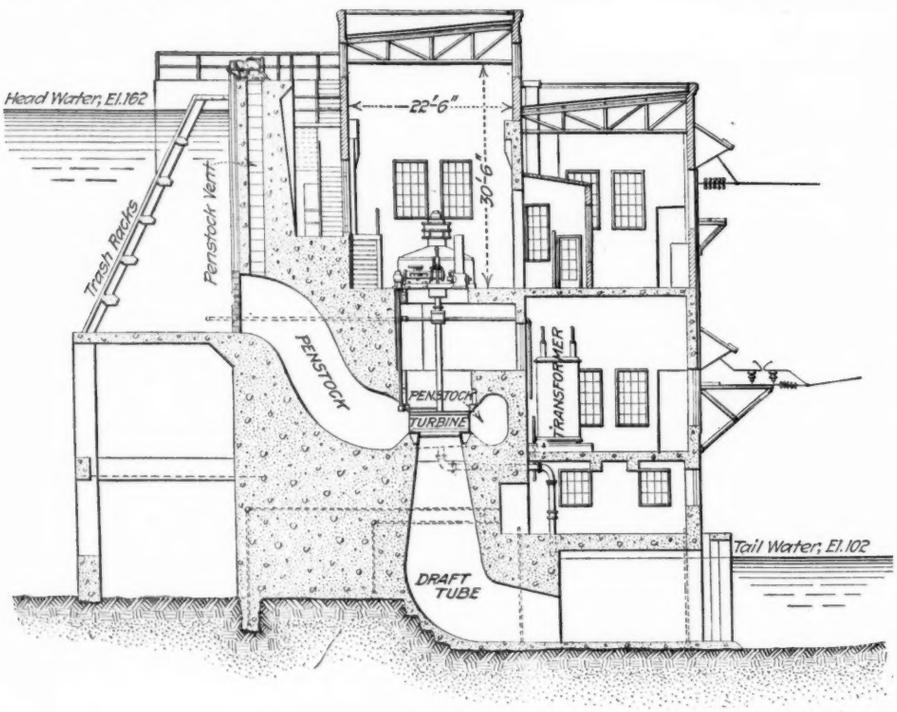

FIG. 2. SECTIONAL VIEW OF THE POWER HOUSE

The main substation, located at Iron River, Mich., contains six 420-kv.-a. single-phase transformers of the oil-insulated, water-cooled type. They are Y-connected on the high-tension side, receiving 66,000 volts between the leads, and delta connected on the low-tension side, delivering 6600 volts. The auxiliary steam plant adjacent to the substation contains three condensing turbine units of a total capacity of 3500 kw. Four 450-hp. internally fired boilers, equipped with Hawley down-draft furnaces, supply the steam. They are served by a reinforced-concrete stack 8 ft. diameter and 150 ft. high. The main transmission line consists of about 45 miles of 66,000-volt lines connecting the hydraulic plants at the Brule and Twin Falls locations with the mining districts of Iron River and Alpha, Mich., and Florence, Wis. The line is in duplicate and is carried on steel towers set in concrete bases. Power is delivered to each mine from the high-tension substation at 6600 volts and is stepped down to 2200 volts for general distribution around the mines. Practically all the secondary lines are in duplicate and are carried on steel towers. Secondary substations are installed at each mine by the power company, the customer providing the necessary building. The equipment consists of three single-phase transformers, automatic oil switch, control panel with all necessary instruments, relays and measuring transformers, and complete sets of electrolytic lightning arresters and choke coils. The secondary substations carry a typical mining load consisting of air compressors, pumps, hoists, motor generators for underground haulage, crushers, blowers, shop

motors and lighting above and below surface. Motors of 25 hp. or over are with but few exceptions operated at 2200 volts. This practice of furnishing power to these iron mines is much the same as that

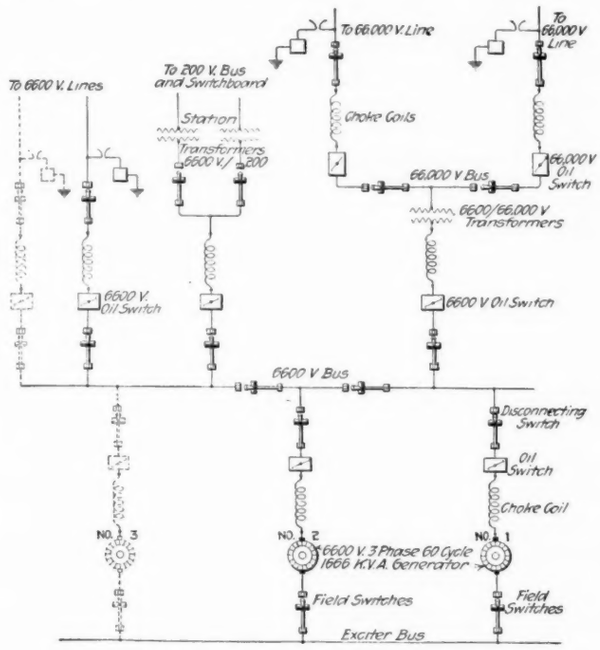

FIG. 4. DIAGRAM OF ELECTRICAL CONNECTIONS

now carried out with several coal mines in other sections of the country, the great plant at Windsor, W. Va., and those of the Appalachian Power Co. being typical examples.

Checking Motor Field Coils

BY E. C. PARHAM

Even where hundreds of field coils of the same kind are made yearly, mistakes in marking the terminals occasionally occur and these mistakes inevitably give trouble and expense. The percentage of mistakes found on factory-made coils is so very small that it is customary to accept their markings as correct and to install the coils accordingly. Where spare coils are made by repairmen or where there is for any reason doubt as to the markings or where there are no markings, considerable delay and expense may be saved by subjecting the coils to preliminary polarity test. Especially is this course advisable where a heavy machine is involved or where lifting facilities for handling the machine are poor.

After trying out a large 500-volt six-pole shunt-wound direct-current motor, it became evident that a compound-wound motor was needed for the work. A set of field coils was obtained from a local repair shop. The terminals of the coils were not marked and the manner of bringing out the leads was not evident. In order to avoid installing the coils to give wrong polarity, they were arranged as shown in Fig. 1, before installation, and the adjacent terminals of the shunt coils were connected as indicated. Line voltage was then applied to the series of shunt windings and a compass used for indicating their polarities. It was necessary to turn one coil end for end in order to have the polarities alternate N and S.

Leaving the coils in position, Fig. 1, the series coils were connected in series and current passed through them and their polarity tested. Of course a heavier current was required for testing the series coils, and in order to get a current that would give definite compass testing result, it was necessary to pass through the coils the operating current of a neighboring motor by making connections as shown in Fig. 2. The result of the test was to locate a reversed series winding on one of the

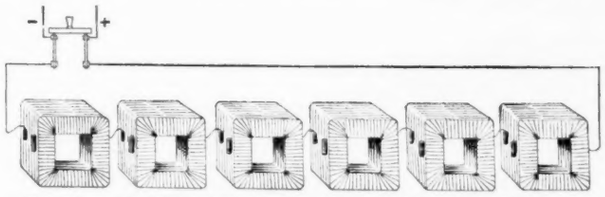

FIG. 1. CONNECTIONS FOR CHECKING SHUNT-FIELD COILS BEFORE INSTALLATION

coils. Therefore, in installing this coil in the motor it was turned end for end, which reversed the polarity of the shunt winding of that coil, if it were to be connected up symmetrically. In order to rectify these conditions, the connections to the shunt winding of this coil were crossed, which did not make a very good-looking job, but saved considerable time in getting the machine into service. After the coils were in the motor, the tests were repeated and everything was found to be all right. As a final check, made in order to insure

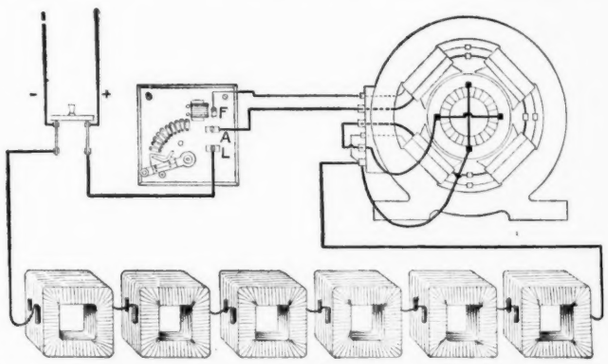

FIG. 2. CONNECTIONS FOR CHECKING SHUNT-FIELD COILS BEFORE INSTALLATION

that the shunt windings and the series windings would operate the armature in the same direction, the motor was started; first, by means of the shunt coils and then by means of the series coils alone. In doing this care must be exercised not to cut the starting resistance out when the machine is operating as a series motor, or it will race and may injure the armature.

A pump may operate stiffly with uneven strokes owing to the swelling of fibrous packing in the water plungers, particularly if the liquids pumped are hot. The swelling is usually lateral so that a layer may be stripped from one side to thin the packing down. New packing should soak over night in warm water and should be loosely packed in the space provided, so that when put to work it will swell and fit as required.

The title of the article on page 759 of the May 20 issue of *Power* should read "Blauvelt" instead of "Du Bois Piston Ring" etc. This ring can be obtained from F. N. Du Bois & Co., 9th Ave. and 25th St., New York City.

Pulling Conductors into Conduits*

BY TERRELL CROFT

Discusses the different methods of installing conductors into conduit and the precautions that must be observed to do the work properly.

METHODS of installing conductors in conduit runs which are in position may be classified under three different headings; namely, drawing, threading and pushing. Drawing consists in pulling the conductors into the conduit by means of a pulling-in line of one sort or another to which the conductors have been temporarily attached. Threading consists of threading the conductors through the conduit as it

FIG. 1. BRAIDED CORD FOR PULL-IN LINE

is erected length by length. This method, while it is used to some extent in England and on the continent, is never followed in North America because our electrical codes specify that "the conductors must not be pulled in until the conduit system has been erected as a complete unit." Pushing consists in forcing the conductors through the conduit run from one of the outlets by exerting manual pressure on them. This method is applicable only where the conduit run in which the conductors are to be installed is short and straight; that is, it can be used only for "easy runs."

Galvanized steel wire makes an excellent pulling-in line, No. 10 or 12 B. W. G. being ordinarily used. If one strand of the wire is not sufficiently strong to sustain the stress imposed, several strands arranged in parallel can be used.

Rope or cord pulling-in lines are probably used more frequently than the other types. Braided rope, Fig. 1, of the construction of that used for sash cord, is ordinarily used for rope pulling-in lines, although in many cases, for heavy-pulling runs, galvanized-steel wire

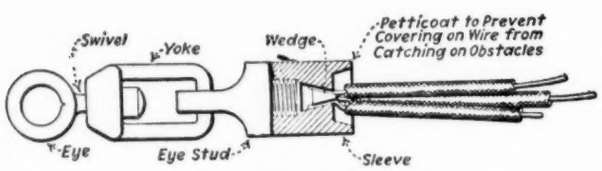

FIG. 2. SWIVEL TO PREVENT TWISTING

is better. Twisted manila rope is sometimes used, but it tends to untwist when subjected to tension. The insertion of a swivel, Fig. 2, between the end of a twisted-rope pulling-in line and the conductors to be drawn in will, in a measure, obviate this difficulty. In untwisting, the rope twists the conductors within the conduit, which causes them to "pack" and pull hard around the elbows. Braided rope, or, as it is called by the trade, "cord," is manufactured in a variety of diameters from $\frac{7}{32}$ in. up to $\frac{1}{2}$ in., and sometimes cords of larger diameters may be obtained. Steel hoisting cable such as that used on cranes has been tried by the writer for pulling-in lines, but because of its high cost and tendency to cut when tied to a tackle-block hook, it was not found satisfactory.

Galvanized-steel wire is better than rope for heavy work. The rope is much more bulky for the same strength, is more expensive and wears out more quickly under severe usage. It is difficult to tie a rope to the hook of a set of tackle blocks with a knot which will not cut and thus sever the line. Galvanized-steel wire can be quickly and positively secured to a tackle-block hook through the agency of a wire grip similar to that shown in Fig. 3.

Steel sash chain makes a good pulling-in line for some purposes. It is very strong, flexible, readily obtained and economical. That of the construction of Fig. 4 has been found very satisfactory. Conductors to be drawn in can be readily attached to the sash-chain line at any point by tying them into the links. This feature is particularly convenient where there are a number of outlets along a run and conductors that are to terminate in each are to be drawn in simultaneously. In pulling conductors into a vertical run, the sash chain may, of its own weight, be dropped down through the tube, rendering fishing unnecessary.

Excessive force should not be necessary to draw the

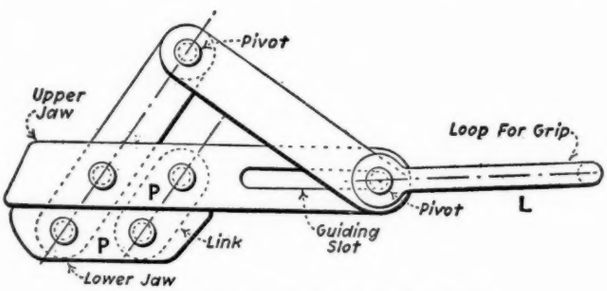

FIG. 3. PARALLEL-JAW WIRE GRIP

conductors into the conduits. This caution should be interpreted in a relative sense. It should always be possible to pull No. 14 conductors into the ducts with the hands, where heavy cables may require a tackle or a crane. In any event, the conduits should be large enough so that there is plenty of room in them for the conductors, and there should be few elbows between pull or outlet boxes. Undersized ducts and an excessive number of elbows or bends will render pulling in extremely difficult and may, after the conductors have become "set," make withdrawal impossible. One of the features which recommends the conduit system of wir-

FIG. 4. CHAIN PULL-IN LINE

ing is that, with a properly designed system, the conductors can be withdrawn or pulled in at any time.

Prior to pulling in the conductors, the interior of the conduit should be cleaned. Sometimes oil, water, plaster, cement and dirt accumulate inside of the tubes while the building is being constructed. Obviously, these materials should be removed before conductors are

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drawn in. A rapid and effective expedient for cleaning a conduit is to pull a piece of waste through it before drawing in.

Lubrication of some sort is desirable when pulling large-sized conductors into conduit. Particularly is it necessary in hot weather and for long runs. When the insulating compound on the conductors is warm, it seeps through the braid and may adhere to the interior surface of the tube.

Powdered soapstone, sometimes called French chalk, is probably the best lubricant. It may be either blown into the conduit with a piece of hose or applied to the conductors as they are pulled in. In blowing powdered soapstone into the duct, a piece of rubber hose about two feet long is partly filled with the material. One end of the hose is held against the bushing at the conduit opening so as to fill the orifice. Then the wireman blows on the other end of the hose with his mouth, forcing the powder inside of the tube. The wires manufactured by some concerns have a coating of powdered mica applied to the outer braids. This acts as a lubricant and tends to insure easy drawing in.

Greases and oils should never be used as lubricants when pulling in conductors. Materials of this character

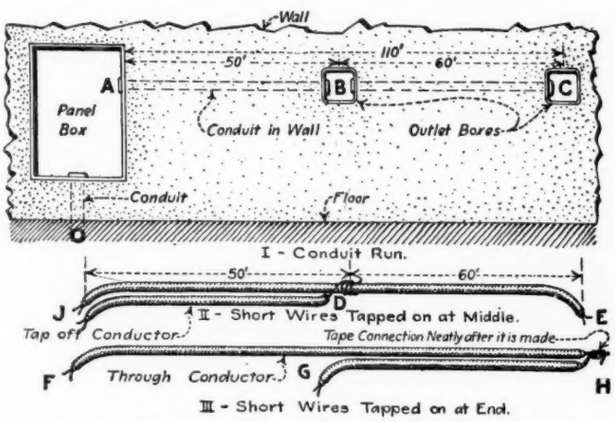


FIG. 5. METHODS OF TAPPING ON A SHORT WIRE FOR DRAWING INTO CONDUIT

act chemically on the rubber insulation and cause it to soften rapidly and lose its insulating properties. The practice of pulling a greased cloth through a conduit run prior to the insertion of conductors is positively condemned. Numerous cases are on record where oil has been poured into ducts for lubrication. Where this has been done, insulation failures, grounds and burnouts invariably result.

Paraffin has been used for a lubricant where conductors are being pulled in, but apparently its use is not frequent. In using paraffin, a block of it is rubbed against the conductors as they are drawn into the tube. Paraffin is a splendid insulator and is therefore unobjectionable from this standpoint. However, it appears to the writer that it is probable that an excess of paraffin on the braids of conductors within the conduit runs would be liable to cause the braids to adhere to the inner walls of the tube and might thereby prevent withdrawal.

In pulling in an easy run, the fishing wire having been fastened to the conductors, the latter may now be drawn into the conduit. If a ribbon fishing wire is to be used for pulling in, it should follow that the conductors are small and the pull light. A heavy pull should not be attempted with a ribbon fish wire as a pulling-in line, as the wire is liable to be rendered unfit for further service. If a greater force is required than can be exerted by two men each having hold of the wire and walking along the floor, either a galvanized-steel wire, a braided rope or a chain pulling-in line should be used.

Conductors can be drawn in by pushing and pulling simultaneously. While one or two men are pulling the

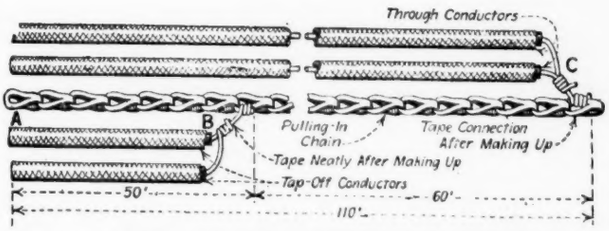


FIG. 6. TAP-OFF AND THROUGH CONDUCTORS ATTACHED TO PULL-IN CHAIN

conductors out at the far end of the run, another man can accelerate progress by pushing or feeding the wires into the other. This man can prevent the formation of kinks and can "ease" the wire over the abrupt edge at the outlet.

It is difficult to obtain a secure grip with the hands on ribbon fishing wire when pulling in; hence it is almost impossible to pull by this method against any considerable strain. Wiremen sometimes bend the bight of the wire around a stick or otherwise distort it to enable them to gain a hold, but this is bad practice. The kinks so formed in the ribbon fish wire can never be removed entirely, although they may be apparently removed. A ribbon thus punished will always give trouble when used for future fishing.

A parallel-jaw grip, or come-along, Fig. 3, can be used in gripping fish wires. If the surfaces of the edges of the two parallel plates, *P* and *P*, between which the wire is clamped are smooth, they will not mar the ribbon. The fact that grips of this type are used successfully for pulling up hard-drawn copper aërial line wire is sufficient recommendation. A spring (not shown

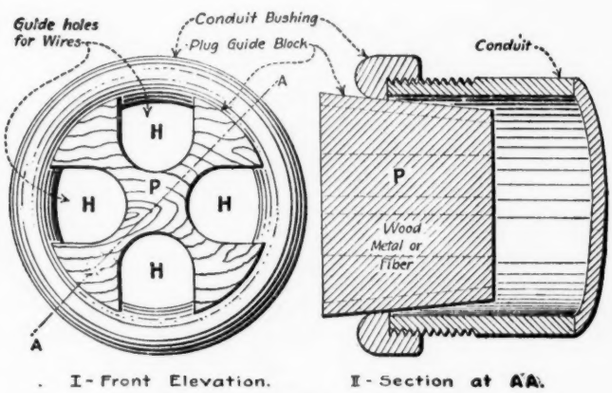


FIG. 7. PLUG-TYPE GUIDE BLOCK

in the illustration) with which the grip is equipped, tends to clamp it lightly on the wire, preventing it from falling off. When a tensile stress is applied at the loop *L*, the clamping effect is intensified. Three sizes of this clamp are manufactured. Each respectively is capable of accommodating a wire of small cross-section

to a No. 6, No. 0 or No. 000. In using the grip, it is clamped on the wire to be pulled and a short rope is tied into the loop *L*. The rope provides a good hold for the wiremen's hands.

Tackle blocks provide the usual method of obtaining the desired force for pulling in a heavy run. One block of the set is provided with a loop and the other with a hook. The block with the loop is made fast to some substantial object, and the hook of the other block is engaged with the pulling-in line.

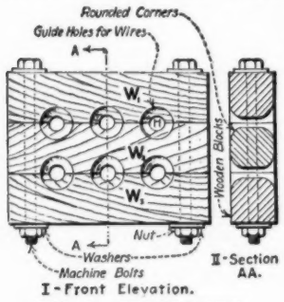


FIG. 8. SPLIT-TYPE GUIDE BLOCK

When drawing in tap-off conductors with through conductors they should all be pulled in together. Tap-off conductors are short conductors that terminate at any outlet nearer to the pulling-in location than the most distant outlet on the conduit run; through conductors are those which extend entirely through the conduit run from the pulling-in location to the farthest outlet. It is practically impossible to first pull into a conduit a portion of the conductors that are to be installed therein and then refish the tube and draw in the remainder. If four conductors are to be drawn in, all four should be pulled through together until the tap-off outlet where the shorter wires are to terminate is reached. Then the short ones should be held stationary while the longer ones are drawn on through to their destinations. Consider the example of Fig. 5. Assume that one conductor is to be drawn from *A* to *C* and another from *A* to *B*. The preferable method would be to draw in the two wires arranged as shown at *III*, being spliced together at *H* for pulling in. When the pair has been drawn from *A* as far as *B*, *GH* would be disconnected and held stationary, but *FH* would be pulled on through to *C*. Difficulty may be experienced if an endeavor is made to fasten the short tap-off wire around the insulation of the other wire, as at *D*. The attachment is liable to fail—slip and jam in the conduit and cut into the insulation.

In pulling in tap-off and through conductors with a chain pulling-in line they can be attached to the line

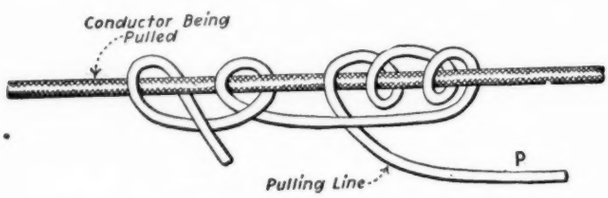


FIG. 9. ROLLING HITCH FOR PULLING WIRE

as proposed in Fig. 6. The through conductors are assumed to be 110 ft. long, are attached to the chain pulling-in line at *C*. The tap-off conductors, assumed to be 50 ft. long, are fastened to the pulling-in line at *B*. This method is feasible with a chain pulling-in line because of the ease with which the conductors to be drawn in may be attached at any location.

Always where a number of conductors are being drawn into the same conduit they should be free from kinks and should be guided into the tube so that they will not twist about one another and foul. Unless these precautions are observed, the conductors may twist into a cable within the tube and bind.

Guide blocks may be used to insure that a number of conductors that are to be pulled in will enter the conduit parallel to one another and prevent the twisting which may render it difficult or impossible to pull in or withdraw the conductors. Where guide blocks are not available, the wires may be guided through the fingers of the man who is feeding. The guide block *P* detailed in Fig. 7 is a plug, ordinarily of wood or fiber, tapered to fit snugly the outlet bushing. Parallel slots *H* guide the conductors into the tube. Where the expected service will justify the expense, this plug *P* may be of metal, machined smooth. Another form is portrayed in Fig. 8. It consists of three strips of wood, W_1, W_2 and W_3, clamped together with two machine bolts. The conductors are guided by the holes *H*.

Where possible it is best to pull from the distribution cabinet toward the lamp, switch or motor outlets. Where this procedure is followed, the coils of wire are

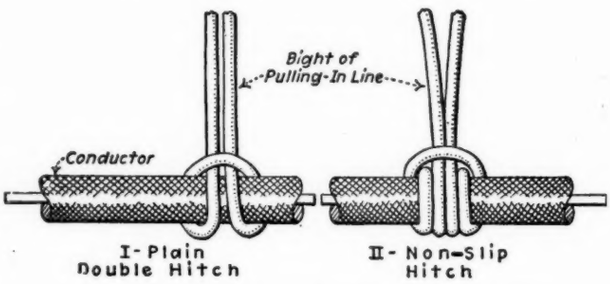


FIG. 10. NONSLIP HITCH FOR PULLING WIRE

all fed from one location, which minimizes unnecessary handling. Furthermore, when all the wire that is being fed in is concentrated at one location, it may be watched more readily.

Conductor ends should be left extending from the outlets to permit of splicing, making up and tapping on through wires. At switch and fixture outlets a free end, six inches long, is ordinarily sufficient where the conductors are small, but where they are large, a greater length may be necessary. At the panel boxes or switchboards, the proper length for the extending free end will be determined by conditions. The conductor must be long enough to reach the switch or cutout terminals to which it is to be connected. After the conductors have been pulled in, the next steps toward the completion of the installation are connecting and soldering.

In tying a rope-pull line direct to heavy conductors, such as might be the case if the latter were being pulled out of a conduit, a knot of any one of several types may be used. In Fig. 9 is given the "rolling hitch," which will grip firmly into the insulation on a large conductor. All the turns should lie close together and be pulled up tight before the pulling stress is imposed. Half-hitches made around the conductor at the pulling end *P* of the knot will increase its gripping power. Another knot, which has been called a "non-slip-hitch," is reproduced in Fig. 10 at *II*, in which a sling is used. To tie the knot, pass the bight of the sling around the conductor and pass the sling through the bight as shown at *I*, making a plain double hitch. Now pass the bight around the conductor again and slip the end of the sling through the bight. Pull the strands tight and the resulting knot will appear as at *II*. This hitch is very easily tied and is extremely effective.

Ammonia Required for New Refrigerating Plant

By J. Kilian

The Parktown Packing Co. was planning an addition to the packing house and engaged the well-known packing-house architects, Binks & Jones, to make the lay-out and specification. When work was fairly under way, Mr. Brown, the president of the packing company, called Jimmy, his chief, into the office and delegated him to run up to Chicago to look over the plans as laid out by the engineers and see if he had anything to suggest as to the mechanical layout. Jimmy, although he cannot boast of having a college degree, has had a world of practical experience around packing houses and Mr. Brown has full confidence in him.

After arriving in Chicago and checking in at the La Salle, Jimmy hied himself over to Binks & Jones' office. He went over the layout with them and made a number of suggestions which were duly taken. "Why do you specify that the contractor shall charge the plant with 2000 lb. of ammonia?" he asked of George, one of the four M.E.'s in the drawing room. "Why, I figured it," said George. "I don't think it is possible to figure the exact amount to be furnished," said Jimmy, "and believe you ought to specify that the 'required amount' be furnished, as no one can tell in advance exactly what is necessary." "Oh, but I have a rule that works O. K. every time," said George. "So have I," said Ed, another one of the designers, "and mine is right every time, too."

This brought about a general discussion of the matter, and it developed that each of the four engineers in the office had his own method of estimating the quantity of ammonia required. As Jimmy was a little weak on this subject, he determined then and there to get the data. He bethought himself of the "seven-centers" in his pocket, and in a few minutes, under the soothing influence of the smokes, he had secured the four methods, which were as follows:

George's method:

¼ lb. per running foot of 1¼-in. ammonia evaporating pipe.

⅓ lb. per running foot of 2-in. ammonia evaporating pipe.

¼ lb. per running foot of 1¼-in. ammonia pipe, flooded system.

25 lb. per 12-pipe high-standard double-pipe ammonia condenser, 2-in. and 1¼-in. pipe and proportionately more or less for higher or lower condensers.

50 lb. per coil of atmospheric ammonia condenser and proportionately less for lower condensers. Pipe, 2 in.

Liquid receivers to be half full, which means:

For 8-in. diameter receiver, 6.9 lb. per foot length of receiver.

For 10-in. diameter receiver, 10.0 lb. per foot length of receiver.

For 12-in. diameter receiver, 15.0 lb. per foot length of receiver.

For 16-in. diameter receiver, 27.5 lb. per foot length of receiver.

For 20-in. diameter receiver, 43.75 lb. per foot length of receiver.

For double-pipe brine coolers, standard-length, 3-in. and 2-in. pipe:

4 pipes high, 27 lb. per coil for evaporative type, 67 lb. for flooded type.

6 pipes high, 40 lb. per coil for evaporative type, 100 lb. for flooded type.

8 pipes high, 53 lb. per coil for evaporative type, 133 lb. for flooded type.

10 pipes high, 67 lb. per coil for evaporative type, 167 lb. for flooded type.

12 pipes high, 80 lb. per coil for evaporative type, 200 lb. for flooded type.

14 pipes high, 93 lb. per coil for evaporative type, 233 lb. for flooded type.

16 pipes high, 107 lb. per coil for evaporative type, 267 lb. for flooded type.

Ed's method:

1¼-in. ammonia evaporating pipe:

For short coils up to 300 ft. long, 7 running feet of pipe per 1 lb. of ammonia.

For long coils above 300 ft. long, 8 running feet of pipe per 1 lb. of ammonia.

For flooded coils, ¼ lb. per foot of pipe.

2-in. ammonia evaporating pipe:

For short coils up to 200 ft. long, 3 running feet of pipe per 1 lb. of ammonia.

For long coils above 200 ft. long, 5 running feet of pipe per 1 lb. of ammonia.

For coils to go into air-conditioning apparatus, coils to be figured about one-half full.

For flooded coils, 0.7 lb. per foot of pipe.

15 lb. per coil of standard-length double-pipe ammonia condenser, 12 pipes high, 1¼-in. and 2-in. pipe.

60 lb. per coil of standard length atmospheric ammonia condenser, 24 pipes high, 2-in. pipe.

100 lb. to 200 lb. for the liquid receiver, depending on the total amount in the system and size of receiver; 50 lb. or less for receivers of small plants.

Frank's method:

For ammonia exaporating system figure 1 lb. of ammonia per 4 to 6 ft. of 2-in. pipe, and 7 to 15 ft. of 1¼-in. pipe, for fairly high temperature work; the quantity to be increased for low temperature work.

For flooded system use ¼ lb. of ammonia per running foot of 1¼-in. pipe and 0.9 lb. per running foot of 2-in. pipe.

Ammonia condenser not considered.

Liquid receiver to be figured half full.

For shell and tube brine coolers figure two-thirds of net volume, allowing for the tubes. Figure 37 lb. of ammonia per cubic foot.

Bill's method:

Ice tanks of 15 tons to 25 tons capacity, ¼ lb. per foot of 1¼-in. pipe.

Ice tanks with coils of flooded type, ⅓ lb. per foot of 1¼-in. pipe.

Evaporating pipe in rooms, 6½ to 7 ft. of 1¼-in. pipe per 1 lb. of ammonia.

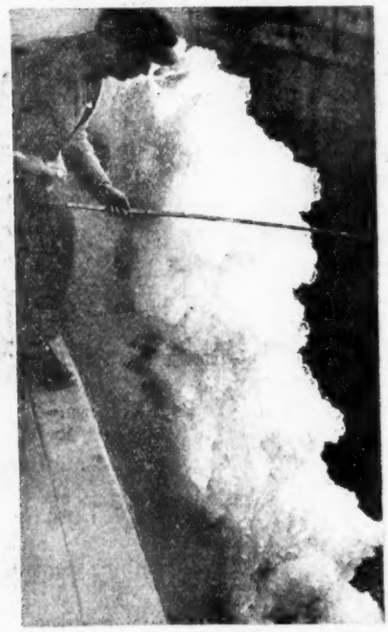
Evaporating pipe in rooms, 4 to 5 ft. of 2-in. pipe per 1 lb. of ammonia.

Ammonia condenser not to be considered.

Liquid receiver to be about one-third full.

For standard shell and coil-type brine coolers, as follows:

Tons	Quantity, Lb.	Tons	Quantity, Lb.	Tons	Quantity, Lb.	Tons	Quantity Lb.
1	20	8	48	25	235	65	590
2	22	10	63	27½	240	75	700
3	29	12	70	30	275	100	830
4	35	15	80	40	350	125	1300
6	45	20	205	50	410	150	1600



Operation at Holtwood

HANDLING ICE SITUATIONS

By
Charles H. Bromley

The articles on Holtwood operating features would not be complete without a description of the successful handling of ice difficulties at the plant. Ice is the most unmanageable trouble maker in a hydro-electric plant. It can be compared with badly clinkering coal in a steam plant, but it is worse than the worst coal under the boilers. The steam man knows that some clinkers may reduce the boiler output and in time may burn up grates; others, if not properly handled, may fill up the air openings of the grates so badly that the fuel bed will produce only a small portion of the effective heat that it is supposed to give off to the heating surface of the boilers. In the hydro-electric plant, however, it is easily possible that a certain kind of ice may shut down the entire station by preventing water from entering the turbine passages.

JUST as there are different kinds of bad coal, so there are different kinds of trouble-making ice in the river water. It would be well to define and name them: Floating cake ice, frazil ice, and anchor ice.

Floating cake ice is well known to everybody who ever saw one of our larger streams in the moderate or northern climates carry off millions of tons of up-river ice down to the lower reaches. This kind of ice passes every year to the Holtwood plant, but has never interfered with its operation.

Frazil ice is formed during cold weather and high wind in the absence of a protecting layer of ice on the river or "lake." The water becomes chilled a little below freezing temperature, then needles of ice appear, and these, by sticking to racks, gates and turbine parts, choke off the water supply to the turbine or prevent operation of the turbine gates. The frazil ice lasts until a rise in temperature comes, as with the rising high of the sun, or decrease in velocity of cold wind, or rise in its temperature. Frazil ice does not occur when the lake is entirely frozen over. However, a few open places in the lake are sufficient to cause trouble at the power house.

Anchor ice is formed when there is no surface ice, or only a very thin coating, especially on clear, cold nights. This ice forms on the bed of the river and with a rise in temperature, usually a little after sunrise, becomes detached in huge masses of slush. Trouble arises so quickly that preparations are made for it long in advance, a close watch being kept for those conditions that produce such ice. The gatehouse water temperature is watched very closely as it approaches the freezing point. A gas-bulb recording thermometer is used, although it is not wholly relied upon, and is checked by a spirit thermometer submerged in a test bucket. This is particularly true when the water closely approaches the temperature at which frazil ice is likely to form.

Test Chain Used as Frazil Ice Indicator—When frazil ice threatens, half-hourly examinations of a chain, kept in the gagehouse, immersed in the flowing water of the forebay, are made. The ice needles attach themselves to the chain when they begin to form. The chain is tied to a rope, and it is interesting to know that ice crystals will adhere to the "whiskers" of the frayed end of the rope before any crystals will adhere to the chain. In other words, the presence of frazil ice will be revealed by the frayed rope quite awhile before crystals can be seen on the chain. This is the experience at Holtwood.

It was for long thought that high river flow—that is, considerably above the station demand, was not a condition when frazil ice could form owing to the flow of

comparatively warm water from small streams and surfaces. More recent observations, however, during river stages more than double the power-house draft, have contradicted this theory

Another Warning—On days when frazil ice threatens, a 50-hp. turbine-driven, hand-control pump is operated continuously at a fixed gate opening, and its speed frequently observed. The inlet to the penstock of this turbine is protected by a closely spaced screen area, which has a tendency to clog up long before frazil ice sticks to the wider spaced screen bars of the main units. Decrease in speed otherwise not explainable by external load conditions will be one of the first indications of imminent ice troubles, sometimes accompanied by a rumbling noise in the turbine casing. Trouble of this kind usually comes in the morning preceding the peak load.

Handling of the Screens—From Nov. 15 of each year until Mar. 15, during the "open" winter season—that is, when the lake is not completely frozen over—it is the practice to run without some of the screens in the turbine intakes. Should the screens be left in, they would become clogged with ice and shut down the plant. However, precaution must be taken to care for the trash that is likely to come down with a freshet at almost any time.

Each intake has five screens in it. The uppermost screen is removed entirely as it is usually above the water level. The second and third screens are linked together by pieces of steel cable and are drawn up out of the water and suspended in their guides by blocking on the gatehouse floor in such a manner that they can be quickly lowered in case an unusual amount of trash should appear in the water. They are tied together so they can be handled quickly. The fourth and fifth screens are left in place at the bottom of the intake.

There are so many screens to be handled that if facilities for rapid handling were not provided, the station output might be materially reduced before the screens could be removed, as the ice accumulates very rapidly. Furthermore, should the screens become clogged and the water level in the pits not watched closely, the difference in water level in front and in back of the screens is liable to crush them. The present practice of handling the screens is considered by the Holtwood operating men to be quite an improvement over the system of a few years ago, when the screens on three intakes were left in place up to the time of imminent ice trouble, while the screens of the fourth intake were removed and its headgate closed. The raising of the fourth headgate insured at once about 50 per cent. turbine capacity, even if all the screens of the other intakes were clogged. The removal of the upper rows of screens on the other intakes, during the frazil-ice run, then increased gradually the capacity of the unit, but it was a slow procedure because of the large number of screens that had to be handled.

Before the winter season the area in front of the racks is cleaned of all débris by divers, as submerged trash may enter the intakes after the removal of the screens. When ground or anchor ice comes, this is particularly the case, because the anchor ice tends to pick up and float water-logged ties, trees, etc., which lie on the river bed. This is a time when the operator must exercise unusual vigilance and listen for unusual noises in the turbine and take proper precautions in case of fouling of the turbine-gate rigging.

During the winter the gatehouse is maintained as warm as possible by the heated air from the generator room. Particular care about this is taken during times when ice formation is likely to occur.

Precautions with Exciters—During the open winter season one exciter has three of its screens removed. Ordinarily, only the motor-driven exciter and the turbine that has the intake protected by screens are used. The storage battery for exciter service is always maintained fully charged.

A dinkey boiler has its fire going all winter, except when the river is completely frozen from shore to shore. A steam-hose connection from boiler to a header, with permanent connections to each turbine, is provided, so that live steam may be available for thawing ice in the wheelpits of exciters or main units.

Imminent Ice Trouble on Main Unit—As soon as frazil ice is noticed, customers are notified to be prepared for taking over a portion of their loads on the steam plants. The Holtwood station output is deliberately reduced by the capacity of one turbine unit, as a precautionary measure, and the other units are operated at slightly reduced gate opening, so that the flow of water through the turbine vanes is as nearly tangential as possible. It has been found that the ice adheres to the vanes less rapidly when the water does not impinge directly on them. This means that the station output is reduced to about 70 per cent. of normal.

The headgates on the unit out of service are lowered and the wheelpit is heated with steam from the dinkey boiler. This unit is held in reserve.

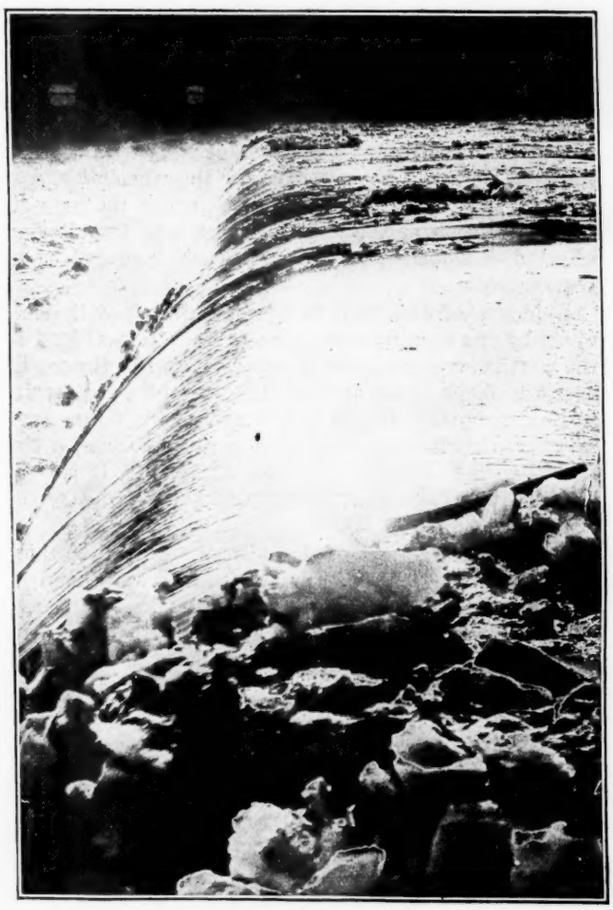


FIG. 1. ICE GOING OVER THE DAM AT HOLTWOOD

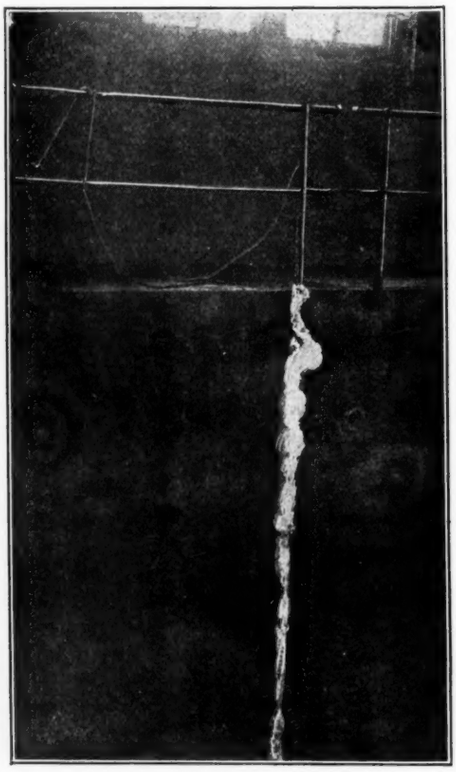


FIG. 2. FRAZIL ICE ADHERING TO CHAIN DROPPED IN WATER IN FRONT OF THE SCREENS

The units in service will gradually accumulate ice; those nearest the river more rapidly than the others. The gate-opening mechanism is kept moving slowly all the time, as this greatly helps to keep the ice from freezing fast to the mechanism. The water level in the pit is watched constantly on the pressure gages on the main floor, so that cold air cannot enter the wheelpit and accelerate the formation of frazil ice around the gate rigging. As soon as the output of any unit is materially affected, it is taken out of service and replaced by the reserve unit.

Evidence of the turbine passages filling with ice is given by the turbine carrying less than normal load for the particular gate opening observed at the time. The operator keeps in touch with this through the floorman, so he can quickly throw in the spare unit when necessary. He must avoid keeping a unit in so long a time that the ice freezes thickly in the passages, because of the relatively longer time required to thaw a heavy coat of ice.

Clearing Main Unit of Ice—On the unit that shows reduction of output, the headgates are lowered and the pit drained. A quick inspection of the wheel is made if load conditions permit. Live steam is then admitted to the wheel pit. The purpose is to heat the ice adhering to parts of the turbine to the point where it loses its adhesiveness. In about twenty-five or thirty minutes the ice is sufficiently loose, so that it washes out when the machine is put back on load and the gates moved a few times. Operation is resumed and continued until the parts again collect sufficient ice to require steaming. Each unit as it clogs up is taken out of service and steamed.

Treating Ice on Exciter Wheels—The motor-driven exciter is loaded fully, so that the waterwheel exciter carries as little load as possible. The less load carried on the turbine the slower will be the accumulation of ice. Direct-current driven station auxiliaries are transferred to alternating-current driven outfits as far as practicable. The other exciter pit is drained, heated by steam and held in reserve.

When the operating exciter becomes clogged with ice, it is replaced by the reserve exciter, the headgate lowered, and steam admitted until the ice has thawed sufficiently to be washed out.

Organization of Crew—At the first indication of ice trouble, all concerned are called out by means of a special whistle and by telephone. The operator solely is held responsible for diagnosis of conditions productive of ice. Definite duties are assigned to each man, provision being made for one or more substitutes in case some men are not available just at that time. The detailed assignment of duties, which follows, gives a good idea of the things to be looked after in the station during a frazil-ice run.

HOLTWOOD ORDER NO. 818

To: Operators and Floormen.
EFFECTIVE: Nov. 26, 1918.
SUPERSEDING: Holtwood Order No. 754 Issued Nov. 15, 1917.
SUBJECT: Emergency Organization and Duties of Maintenance Men in Case of Frazil-Ice Trouble.

During threatened frazil-ice trouble the operator will call out everybody concerned in the operation of the station. Operators shall use the telephone for notifying all those named below, so that they can report to the power house at the earliest possible moment to assist in operation of the station during the threatened trouble. Operators will act in accordance with Permanent Instructions, Section No. 20, *Abnormal Electrical Operation—Ice Trouble.*

In case of the absence of the first man named, the man named immediately below, in parenthesis, shall act.

STABLEY ..... In charge.
(Oppenheimer)

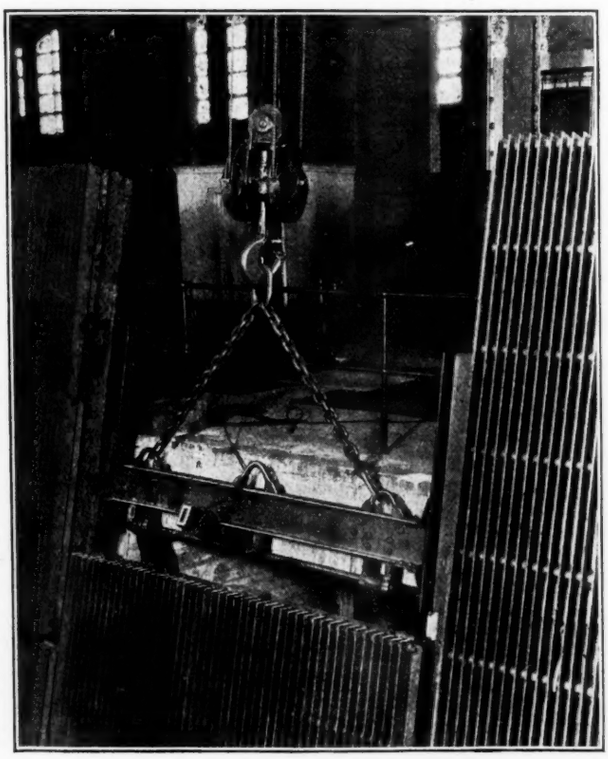


FIG. 3. TACKLE FOR LIFTING SCREENS

OPPENHEIMER ..... (Morgan) (Lowy) (R. D. Shaub)	Keep in touch with station capacity, recording same at frequent intervals, predicting same when necessary and keeping operators informed on these points. Record time of events for purpose of report.
R. D. SHAUB..... (Nichols)	Assist in operation of benchboard, see that turbine vanes are kept moving during the actual run of the ice.
CHRISTIANSEN & MEN.. (O'Neill)	Attend to dinkey. Remove exciter screens. Run gatehouse crane—W. Wells. Keep forebay free of all floating timber while screens are out.
KEATING ..... (1st pumpman on watch)	Attend to tunnel steam. Make and maintain emergency steam connections. See that supplies of miscellaneous fittings, pipes, valves, hose, etc., are on hand for emergencies.
BALLANTYNE ..... (Kauffman) (Wells)	Look after lighting. See that dinkey has sufficient light. See that men working in wheelpits are provided with any additional lights needed. Provide operator for the searchlight and maintain same.
O'NEILL ..... (Abbott)	Attend to opening and closing of wheelpits. Make examination of ice conditions in wheelpits, noting the time of steam on and steam off and method of application, and make written report on same.
LOWY ..... (R. D. Shaub)	Note meteorological conditions. Note amount of ice in forebay, around log booms and on pond, making sketches of same. Note water temperatures and characteristics of ice formation on test chains, screens, dam and any other points of interest or of value as research data. Notify operator of any anticipated sudden and marked drop in head due to ice hanging on dam clearing off.

Signed,

T. C. STABLEY,
Chief Operator.

Service Record of Frazil-Ice Occurrences—The foregoing methods of handling ice at the Holtwood station are the result of many years of experience and experiments. During the first few years of the operation several service disturbances occurred, due to the screens, turbines or exciters becoming clogged with frazil ice. On the occasion of the first frazil-ice run in January, 1912, the installation of the motor-driven exciter and of the large storage battery was not yet completed, resulting at that time in the only total interruption of service experienced at the plant due to frazil ice.

In most plants with higher head the problem is considerably less difficult than at Holtwood. There are very few stations where, if the screens are removed, the ice will not go through the turbines without clogging them. A probable reason for this is that in most stations the turbines are set in iron casings exposed to room temperature; at Holtwood the turbines do not have this advantage. A small fraction of a degree above the freezing point seems to be sufficient to prevent the ice from adhering to the turbine parts.

The difficulty is that at the Holtwood Station the double runner turbine units, Nos. 1 to 7, are entirely submerged in a large wheelpit without any opportunity for absorbing heat from the warmer parts of the building. The single runner unit No. 8 has so far been practically immune against frazil-ice formation, probably owing to the better exposure of some of the turbine parts to the warm air of the generator room. The quantity of water handled by the turbine is so large that it is impractical to heat it by steam or electricity, even to that small fraction of a degree which is necessary to prevent the frazil ice from adhering. The energy required to heat the water $\frac{1}{100}$ deg. C. would equal about one-third the output of the station.

Many different methods of screen handling, turbine heating, loading of units and ice detection have been tried and the practice outlined has resulted. While an ordinary ice run lasts but a few hours, usually not more than eight or ten, there is on record a case that lasted thirty-six hours, and this was negotiated without any disturbance to customers. Frazil ice seemed an almost insurmountable difficulty at first, but by the system that has been developed at the plant it is not likely that any

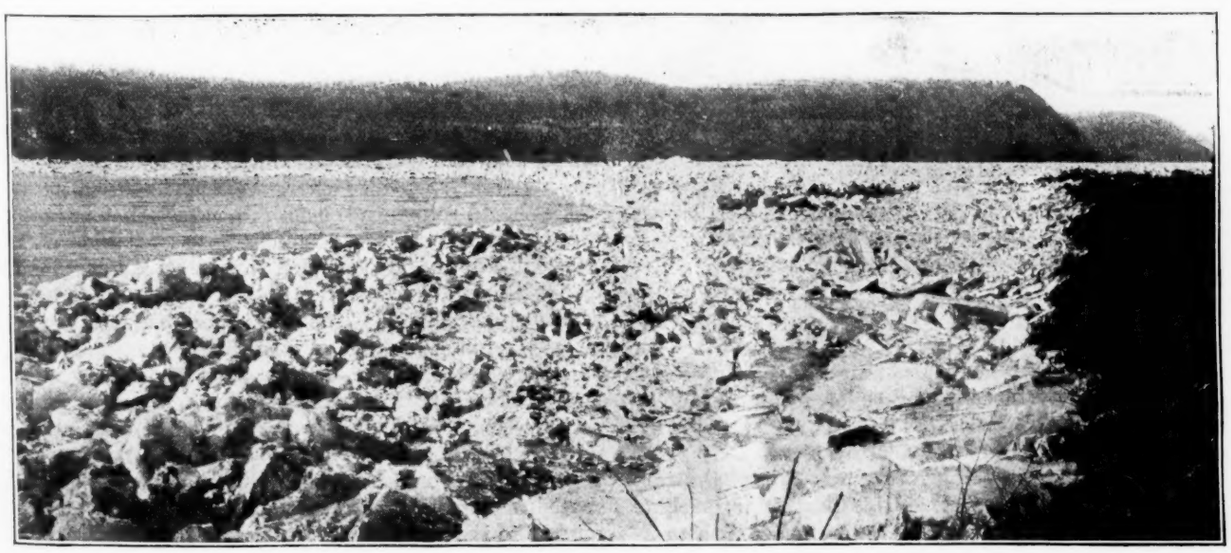


FIG. 4. ICE JAM IN THE SUSQUEHANNA RIVER A LITTLE ABOVE HOLTWOOD

ice run, however severe, will interfere with service to the customers.

Following is a record of all the frazil-ice occurrences since the plant was put in operation (October, 1910) and their effects on the service:

Date	Ice Noted on Test Chain	50 Hp. Turbine Pump Affected	Turbines Affected	Disturbance to Service
Jan. 5, 1912	Not in use	Not in use	Screens and exciters clogged without warning.....	Total interruption
Feb. 14, 1914	Not in use	Not in use	Portion of screens clogged on main units.....	Frequency and voltage disturbance
Jan. 30, 1915	3:55 a.m.	3:55 a.m.	8:00 a.m.	None
Jan. 15, 1916	3:00 a.m.	4:30 a.m.	5:45 a.m.	None
Jan. 17, 1916	6:30 a.m.	6:30 a.m.	8:25 a.m.	None
Feb. 10, 1916 (Anchor Ice)	5:55 a.m.	5:50 a.m.	Not affected	None
Mar. 16, 1916	5:45 a.m.	Not affected	Not affected	None
Dec. 16, 1916	7:00 a.m.	Not affected	Not affected	None
Jan. 5, 1919	5:40 a.m.	5:45 a.m.	8:18 a.m.	None
Jan. 10, 1919	4:14 a.m.	4:20 a.m.	Not affected	None

To those who desire further information on ice, its formation and methods of handling it, particularly in hydro-electric plants, the book, "Ice Formation," by Barnes, is recommended.

Auxiliary Source of Gland-Sealing Water

BY C. H. SONNTAG

The amount of water in a spray cooling pond operated in connection with a jet condenser will gradually increase, excepting perhaps in the very hottest and driest wheather, because the water of condensaton, which is mixed with the circulating water, more than makes up for the loss by evaporation. If the pond is allowed to overflow, the water in it will, because of the continuous dilution by condensed steam, become very soft, even if the pond was originally filled with hard

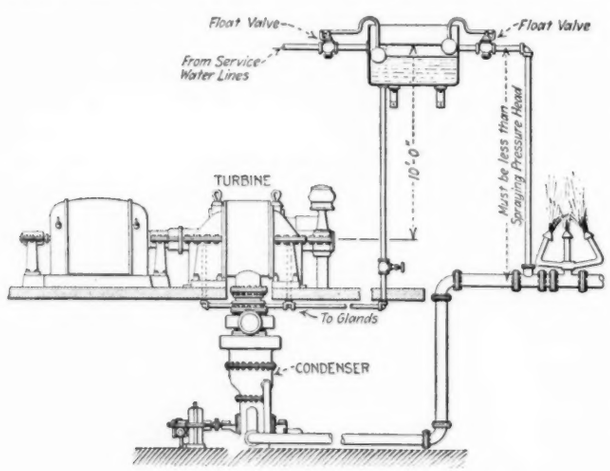


FIG. 1. PIPING OF GLAND-WATER SYSTEM SHOWING RESERVE SUPPLY TANK

water. Such a pond then offers a limited supply of soft water, which may be used for boiler feeding or other purposes.

In a turbo-generator station using a certain type of machine, there is need for soft water to seal the turbine glands. The builders of this particular machine specify that sealing water shall be furnished at a pressure equivalent to a 10-ft. head. If the relative levels of the spray nozzles and turbine permit, the spraying pressure may be used to supply the glands directly. In our plant this condition exists, but we have installed a supply tank as shown in Fig. 1, which gives a reserve supply of soft water. The float valve keeps the tank full and at the same time prevents waste.

Although we have not done it, the tank could be fitted with another float valve at a lower level, which would

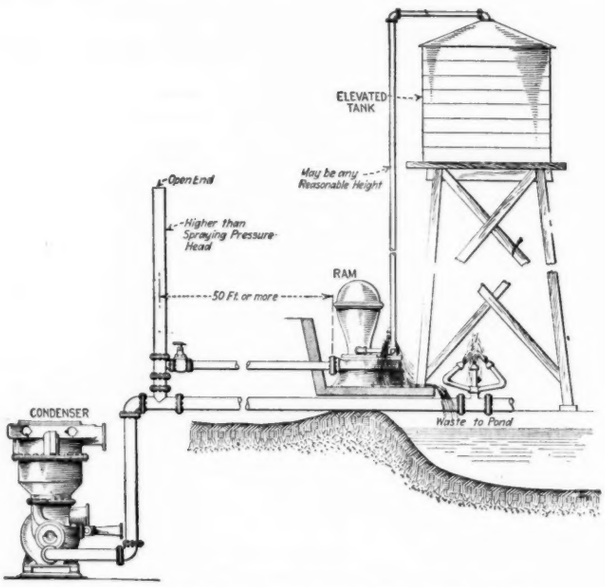


FIG. 2. RAM FOR SUPPLYING GLAND WATER, CONNECTED WITH STANDPIPE

admit water from the general service lines in case the supply of soft water should fail for any reason. The tank could also be fitted with a low-water alarm of any desired type, as a bell or red light. The use of spray-pond water in this way does not really remove any water from the pond, for practically all the loss from the glands is drawn into the turbine, where it mixes with the condensed steam and returns to the pond.

When we installed this system, our turbine glands were badly scaled up and we were about ready to open the machine and clean them. Since using soft water, their condition has steadily improved, and we see no reason why we should clean them, as the soft water seems to be gradually dissolving the scale which was formerly present.

If the spraying pressure is not sufficient to supply the glands directly, a hydraulic ram may be used instead of a steam pump to pump water to the supply tank. It would get its working head from the spray pressure and so utilize energy already available. Its waste should return to the spray pond, so that no water would be lost from the system.

In our case we have avoided the use of a steam pump by installing a hydraulic ram, the arrangement being as shown in Fig. 2. The ram operates with energy already available, and it uses so little water that it has no noticeable influence on the spraying. The standpipe is necessary to give free vent to the air that is mixed with the water from the condenser, so that the pipe feeding the ram shall be filled with solid water. The ram is set on the intake well of the pond, and in a sheet-iron pan in such a way that its waste water all returns to the pond. Hence no water is taken from the circulating system excepting that actually pumped into the tank.

Circulation in Water-tube Boilers

By A. BEMENT

IN THE days of low settings and insufficient flame travel the usual three-pass vertical baffling resulted in smoke production and loss of heat due to incomplete combustion. As a remedy the use of a fire-tile roof over the furnace, fitted to and carried by the lower row of tubes of the boiler, proved to be satisfactory. The application of the tile roof to the type of boiler shown in Fig. 1 was made in a considerable number of cases in which superheaters were installed. As it was not considered desirable to make changes in the location of the superheater or the gas outlet, the manner of gas travel indicated by the arrow was adopted. The result of this arrangement was an increased furnace efficiency. The boiler efficiency was reduced, but not enough to overcome the furnace gain. The degree of superheating, however, was reduced a considerable amount below that obtained with the three-pass vertical baffling where the gases come in contact with the superheater after passing once directly across the tube surface, instead of the longer horizontal bottom and considerable vertical front travel, thus arriving at the superheater at a lower temperature.

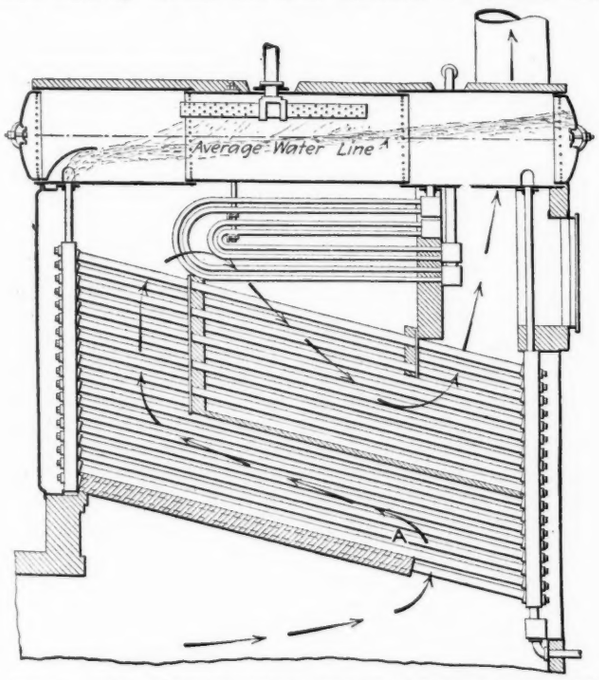


FIG. 1. HORIZONTAL DRUM AND SYSTEM OF BAFFLING THAT CAUSED TOP SURFACES OF TUBES TO DETERIORATE

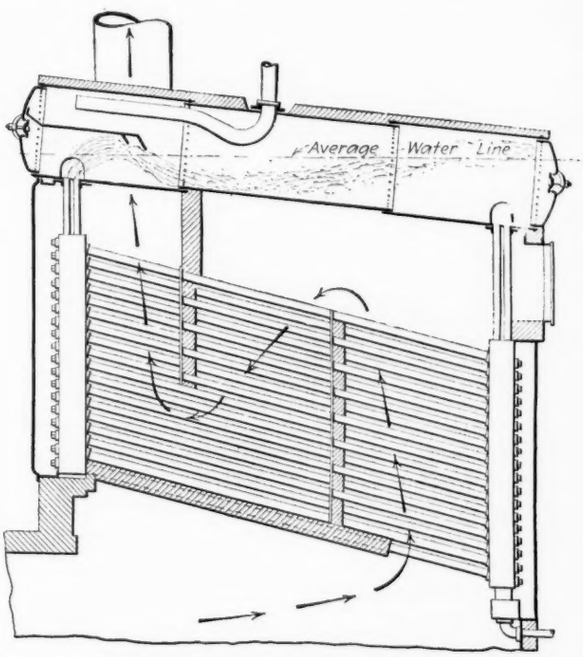


FIG. 2. SHOWING DRUM WITH DOUBLE NIPPLES, IMPROVED BAFFLING AND BETTER SEPARATION OF WATER AND STEAM

In other respects no further unsatisfactory feature was observed until boilers so fitted had been in service a few years. Failure of the tubes in the second and third rows then occurred at the point marked *A*. These failures occurred on the top surface of the tubes, and when removed, they were found at the point of failure to have been reduced to a thickness of about $\frac{1}{32}$ in. This thin portion extended for about two feet in the length of the tube, all other parts being apparently of the original thickness; even the bottom portion just below the thin part showed no evidence of reduction.

A number of theories were advanced in explanation. One was that the gases, after their rush from the furnace, rebounded, taking a downward course and impinging on the top of the tubes at the point of failure, and that the ashes and cinder they carried reduced the thickness of the metal by erosion. This theory does not account for the fact that the gases take the path of least resistance, in a direct line from the point of inlet to that of outlet and would not diverge from this direct line unless they met with some obstruction. As there is no more obstruction at the point *A* than at any other place on the tube surface of the pass, there would be no special reason for divergence here and the reduction of the tube metal due to erosion would be just as likely to occur on the bottom row as at any other place and would be on the directly exposed bottom of the tube instead of the top. No such reduction of metal occurred on any tubes except at the top surface at *A* of principally the second and third rows.

A much better explanation of these tube failures, and probably the right one, is to be found in the water supply afforded at the point *A*. Such boilers are made up of vertical sections, each composed of fourteen tubes, all of which receive their water supply by way of one vertical pipe leading from the drum above. This pipe is of the same diameter as that of the tubes, so that the feeding tube has only one-fourteenth of the capacity of the section that it supplies, and it is reasonable to question its ability to do so properly. Likewise, the outlet at the front is of the same capacity, although called upon to perform even more work, as it must give exit also to the steam with its greatly increased volume. Doubts as to this construction have existed, particularly for loads above rating, but there has been only limited actual knowledge. A case may be cited, however, that may afford definite proof.

A boiler of the type in question, fourteen tubes high

and fitted with a tile roof, had operated with perfect satisfaction for a considerable time. The inclosed furnace produced by the presence of the roof caused a high furnace temperature, proportionately destructive to furnace linings, and it was thought that if a portion of the heat could be absorbed from the gases while still in the furnace, the temperature would be so lowered as to extend the life of the brickwork. To this end the roof was removed at a point just above the fire for a distance of 2 ft., the space above being closed by tiles covering the top half of the tubes. The result for as long as the experiment continued was quite satisfactory to furnace linings, but in four or five weeks the bottom row of tubes at the exposed location over the fire had burned through and required renewal. The opening from the furnace at the end of the roof was 5½ ft. The tube exposure was, therefore, 7½ ft.—and the whole tube for 5½ ft. and the bottom half for 2 ft. The tubes were kept as clean as before, so in this respect conditions were equal. This 2-ft. exposure was not subjected to higher temperature than had been the 5½ ft. at the back, because before the exposure over the fire was made, the full temperature was discharged onto the rear length. The conclusion to be drawn is that the water supply was sufficient for a length of 5½ ft., but not for 7½ ft. It is known from experience in steel mills that in certain kinds of billet furnaces, pipes of much greater length than these boiler tubes may be kept quite cool if water is passed through them in sufficient quantity. Although passing through a region of high temperature, the water may discharge so as to feel barely warm to the hand.

Fast Moving Center of Hot Gas

Referring again to Fig. 1, it will be observed that failure occurred a considerable distance from the inlet end of the tube. The arrow drawn through the heating surface indicates the hot center of the moving gas body. Experiment has shown that the flowing body of gas has a center of higher temperature that moves faster than its surrounding envelope, the latter spreading out more and lagging behind in its movement. Therefore, the hot center at location *A* had reached a point on the tubes where the water supply had become depleted to a considerable extent. The gases of course had been cooled before reaching this point, but were still hot enough to cause damage. So a critical point is reached where the temperature is still high enough and the water supply has declined sufficiently to cause damage. The reason why damage appears on the top surface would be due to the water flowing along the bottom of the tube and leaving steam only in contact with the overheated part. As a few years' time was necessary to produce failure, it is probable that damage was caused in many small installments of short periods in duration, when, owing to especially favorable coal, high boiler capacity was developed, resulting both in depleted water supply and unusually high gas temperature accompanied or immediately followed by some oxidation of the red-hot tube surface.

Fig. 2 shows a method of baffling that is adaptable to this type of boiler and will overcome the difficulties described, and do so even with the prevailing degree of water supply furnished by the 1 to 14 ratio; but the matter of circulation or water supply is of first importance in view of the growing demand for enlarged boiler output. In this connection Fig. 2 shows a double set of nipples connecting both front and rear headers with the drum. This scheme doubles the water-supply capacity without involving difficulties of construction or operation. Transversely, the proportions are in no way changed, it being necessary only to increase the depth of the headers and lengthen the junction boxes on the drums enough to take two tubes instead of one.

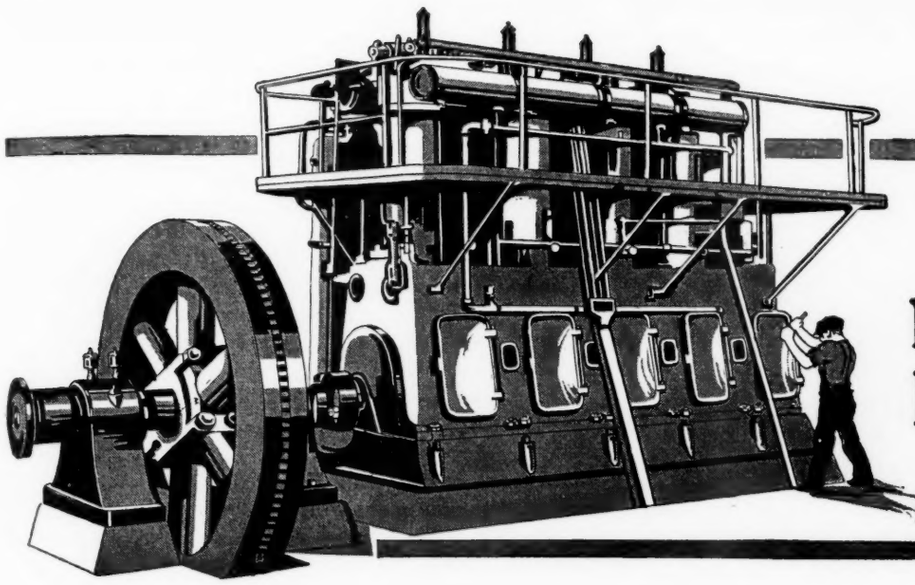
One feature of boilers that has received comparatively limited investigation, but which is nevertheless of much importance, is the separation of the steam from the water. The conclusions here presented are based on much experimental work, a part of which consisted in the use of small boilers provided with glass drums, allowing the visible action to be studied. Fig. 1 shows a typical drum provided with a perforated dry pipe, through which the steam is drawn off. The water in the drum is shown deeper at the rear than in the front, piling up as it flows back. This is characteristic of drum action in all horizontal water-tube boilers. The movement is rapid. Much water rushes up at the front with the steam and flows back as the steam seeks the exit. When driven at high capacity, or when priming occurs, water is carried up with the steam into the dry pipe.

Making Priming Impossible

Fig. 2 shows the drum inclined, sloping back, and provided with a different form of water baffle. Steam is taken from the drum above the baffle at the front by the pipe indicated. The action of this arrangement is to cause the incoming water to be directed back and down in a direction opposite to that at which the steam leaves. The result is complete separation of steam and water under extreme conditions, making priming impossible.

In action, the steam rising to the drum carries with it a large amount of water; in fact, all the water in the boiler is in rapid movement flowing around the cycle. Upon arrival in the steam drum, the bubbles of steam escape and in so doing carry much spray with them. If the space above is sufficient so that the velocity of the rising steam is comparatively low, this spray will drop back, leaving the steam free of water; otherwise it will continue with the steam leaving the boiler. These different actions are illustrated by the two drums shown in Figs. 1 and 2, which also show that the real water lines are not level, the indications of the water glass giving the average level.

As a general practice the water is carried too high in water-tube boilers having drums of the horizontal or sloping type, tending to produce wet steam. As to just how low it may be carried safely in such boilers is not so well understood. When the water drops to the bottom of the gage-glass, it is felt that the danger point has been reached. This is true as far as ability to keep track of the water is concerned, because if out of sight there is no way of knowing where it is. Experiments with the model boiler with the sloping drum showed that the water line as indicated by a specially long gage-glass could be well below the upper tubes at the front, yet circulation continued uninterrupted, with no overheating of the tubes. The rising steam carried the water with it to the drum, whence it flowed back down the slope of the drum to the back nipples. This indicates that if a sloping drum is employed the water line at the front may be carried at the bottom of the drum, thus affording large separating space and insuring great capacity for dry-steam production.



Talks on DIESEL Engines

by L. H. Morrison

XIX—*Egan had been busy and had given little thought to the coming meeting. So, when the evening arrived, he decided to let the men ask questions on matters that they particularly wanted to understand.*

"I INTENDED to take up fuel consumption and tests tonight," said J. R. to the men, "but I haven't had time to get the dope together, so we"ll save that for another time. Instead, I'm going to let you ask whatever pet questions you've been saving up." He turned to the night oiler: "Johnson, what's yours?"

"Hanged if I know, unless it's why an engine smokes."

"Your indecision, Johnson, shows you don't think about your work. A smoky exhaust may be due to one of several things. First, the engine may be overloaded. In this case the fuel pump is delivering more oil than the amount of air—or rather oxygen—in the cylinder can consume. The remedy is to reduce the load.

"Again, it may be due to improper distribution of the fuel charge. By this I mean that only one or two cylinders are receiving any fuel. You can see that in this case the governor will attempt to deliver enough oil to the particular cylinders receiving the fuel to enable the engine speed to be kept up to normal. This overdose of fuel will cause those cylinders to fail to consume it all, so we get a smoky exhaust. The cause of the improper distribution lies either in the fuel pumps or in the oil lines. It may be that the fuel-pump valves leak, allowing the oil from the pump to flow back to the suction line. The remedy is regrinding the fuel valves. It is easy to see if the pump leaks. Just cut out one cylinder at a time. Disconnect the fuel line to the needle valve and see if you get a flow of oil.

"A smoky exhaust may be due to an injection-air pressure too low to break up the oil charge as it passes through the atomizer. The oil then remains in the shape of large drops, and the air can come in contact with only the outside of these, with the result that combustion occurs only on the surface. The exhaust valve opens before the entire drop of oil is consumed, and the particles rush out into the exhaust line still smoking and unconsumed. The remedy is to raise the air pressure.

"Another cause is leaky admission or exhaust valves, which lower the compression temperature in the cylinder until it is too low to cause the fuel to ignite. If you follow instructions about regrinding valves, you won't have this trouble.

"The last cause is one which no engineer should endure—smoking due to excess of lubrication oil. The thing to do is to see that just enough oil is used. Don't think you are playing safe by feeding more than enough.

"Now let's see what Goodhue is laboring over."

"A whole lot of things bother me," admitted the night engineer. "One is why the fuel-cam noses should be adjusted."

"That might be answered by saying it's because they shouldn't, but we'll give a better answer than that. I imagine your question is caused by the fact that we frequently change the cam noses on the old engines.

"From the standpoint of a new engine the noses will not need adjustment within five years of installation. When the engine is tested out at the factory, the noses are properly set. This position is the correct one for practically all fuels. I do not believe the variation in gravity from 20 to 36 deg. Baumé demands any change of the fuel cam. The nose is made of tool steel, hardened, and shows virtually no wear. With the old engines the noses are worn quite a bit. We have experimented with various settings of them. So, Goodhue, the correct answer of why a person should change the cam noses still remains the same—you shouldn't."

"I'd like to put another one, J. R. What is wrong when the engine refuses to start?"

"I will assume that you have the engine set at the proper starting place and your valves in the correct posi-

At the next meeting the Chief will bring to a close his series of informal talks, the subjects being the efficiency of the Diesel engine as compared with other prime movers and the necessity of keeping daily records

tions. The first thing is to note if you have high enough air pressure in your starting tanks. If the engine has a cam relief and starts on low-pressure air, the pressure should be at least 250 lb. per sq.in. If it is of the type in use here, the starting air should be not less than 50 atmospheres, or 750 lb. per sq.in. I don't mean that an engine won't start on 40 atmospheres, but if it's less than 50, you'll likely find that the failure to start is due to the low pressure. If you are running

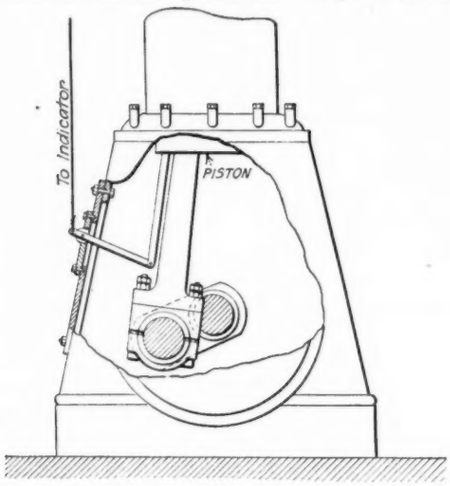


FIG. 1. SWINGING-LEVER INDICATOR RIG

one unit, it's easy to boost up the pressure in the starting bottles."

"What are you going to do in a one-engine plant where the compressor is right on the engine?" Goodhue asked, thinking he had put a poser.

"There is a method that may be used in such cases. Go to your favorite soda fountain and get a charged carbonic-acid bottle, or drum, connect it to one of the starting tanks, crack the valve and let the gas into the bottle until the drum pressure drops to about 40 atmospheres. Put hot rags on the gas drum until the evaporation of the liquid CO_2 raises the pressure up to 50 atmospheres. Then open the valve again. Do this until no further application of heat affects the drum pressure. Then use your bottle of CO_2 to start the engine. One thing, don't ever use ether. I know of an oil engine that broke two cylinder heads and one jacket by a wise guy using ether.

"But let's go back to the question of why the engine doesn't start. Maybe your fuel pump is airbound. So disconnect the lines to the fuel valves, set your pump lever to the filling position and keep the fuel lines disconnected until oil begins to flow out. A few engines have a valve mechanism at the needle valve, so it's only necessary to open this overflow valve. Some make use of a bypass valve, which is opened.

"Then we have another reason. If the engine turns over a half revolution, it indicates that either the air starting valves on the starting cylinders are stuck open or the fuel valves on one of the firing cylinders may be wedged open, allowing the high-pressure air to blow into the cylinder.

"Again, the piston rings may leak so much as to lower the compression temperature below the ignition temperature and the engine will not fire the fuel charge. Still another cause, although not very probable, is the admission of the fuel so late as to prevent combustion.

"The most improbable reason is incorrect timing of the inlet and exhaust valves.

"Woods seems to have something on his mind. Let's have it."

"Why do some engines use water in the exhaust pipe and then again some don't?"

"The idea of the water drip into the exhaust piping is to cut down the noise. If water is forced into the pipe, it cools the hot gases, reducing the pressure and velocity and eliminating much of the noise. An additional advantage is that the water chills the exhaust gases and sets up a sort of condenser effect. The pressure in the exhaust lines being reduced, the back pressure is less, and the friction horsepower is decreased."

"Chief, why does the drip piping from the exhaust pipe rust away so fast? It looks as if some kind of acid eats it."

"It is some sort of acid, Kelly. The usual fuel oil sold contains some sulphur, which is burned to a gas, sulphur dioxide. When it passes out through the exhaust pipe, it comes in contact with the hot water or water vapor and forms sulphuric acid, which eats iron very rapidly."

"If that is a fact, why doesn't it eat the exhaust pipe?" Kelly demanded.

"It does eat it a slight amount, which isn't apparent, because of the thickness of the pipe. The drip lines are made of steel and are eaten much more rapidly, and, since the metal is comparatively thin, of course, it is soon destroyed."

"J. R., since you are on exhaust pipes, tell me why Diesel engines don't use cement exhaust pots. Our hot-ball engine had one."

"The advantage of a concrete exhaust pot is that it costs much less than a cast-iron pot of the same size. With a two-cycle hot-ball engine you must have a big pot to provide enough dampening to kill the noise.

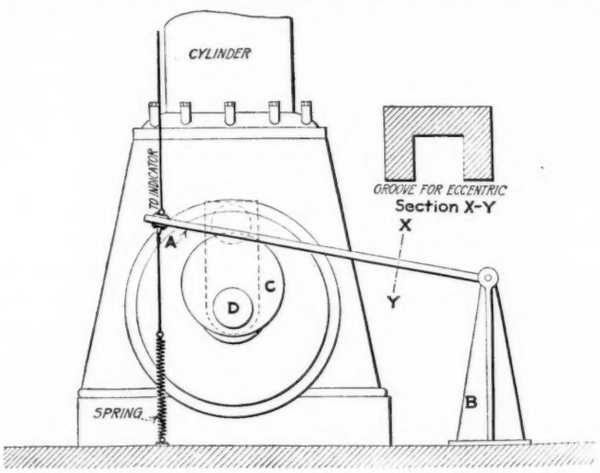


FIG. 2. CAM-MOTION INDICATOR RIG

With a Diesel, especially the four-cycle, the exhaust noise is not so great, and a pot of moderate dimensions is ample. With vertical engines the iron pot can be set above the ground, allowing a drain line. With horizontal engines an iron pot is handier, even though it must be set in the ground."

"If a Diesel don't make much noise, why use a pot that costs money?"

"Of course, there is some noise, Kelly," Egan con-

ceded. "From my viewpoint the pot could be dispensed with if the exhaust pipes were made the proper length. The ways the pot kills the noise are by breaking up the gases as they leave the pipe and by preventing air from rushing into the pipe after the gas has passed out. If the pipe is made the correct length, the first gas charge will be slowed down and just leaving at the moment that the next gas charge is entering the pipe. The space behind the first charge is then occupied by the second charge, and so no air enters the pipe. If the pipe is too long, the passage of the gas is interfered with, raising the exhaust pressure at the engine. I am of the opinion that in most cases no attention is paid to the question of pipe length. Quite often an alteration would lower the back pressure."

"How can you tell which cylinder is missing fire?" the Scotsman queried.

"Simply by removing the plugs from the exhaust elbows, one at a time. Most engines are not provided with these ports, and it's a good idea for the operator to drill $\frac{3}{4}$-in. holes in the exhaust elbows. Personally, I don't see any reason to tap the holes—simply use a brass plug with a handle long enough to keep cool."

"When you hear a pound, how can you tell where it is?"

"Knocks may be divided into two classes—bearing knocks and cylinder knocks. The latter almost without exception are due to some fault of the fuel valve. If the knock is sharp, it is a preignition pound and is caused by the fuel valve opening too far ahead of dead-center. If the pound is rather dull or dead, the fuel valve opens late, and the explosion occurs when the piston is fairly well along on the outward stroke. The knock is caused by the increased pressure forcing the piston pin and the connecting-rod against their brasses.

"Ordinarily, a pound due to worn bearings can be detected at once. To make sure, put the engine on bottom dead-center and pinch upward on the lower edge of the piston with a bar. If it 'jumps' without moving the connecting-rod, you can be certain that the piston-pin bearing is worn. The same test can be used on the big end. Just put a bar under it, when it's on top dead-center, and jump it. As to any wear in the mainshaft bearing, it's seldom it can be detected by any pound.

"Going back to a sharp knock, this could be caused by too high air pressure, which your gage will show. It shouldn't be over 1100 lb. per square inch."

"I've another one, J. R.," Kelly interposed. "You talk about keeping up the compression. How do you know when it's lost?"

"First, you can tell by the way the engine fires. Second, you can use a compression gage. That's a thing I hope to get here. The idea is a small, heavily built tank about 6 in. long by 3 in. in diameter. Inside is arranged a set of baffles. At the top is placed a high-pressure gage. From the bottom a high-pressure pipe with a $\frac{1}{16}$-in. bore leads to the indicator cock. When the cock is opened, the charge enters this little pipe and tank. The pressure builds up to that existing within the cylinder. The baffles prevent the pressure fluctuations from affecting the gage. This will give an approximate value. To be sure the only way is to use an indicator on the engine.

"Our new engines are equipped with an indicator rigging. It's been some months since I used an indicator on the old ones, so for Woods' benefit I'll sketch the rigging. Inside the lower end of each piston we drilled and tapped two $\frac{5}{8}$-in. holes and attached the lug. Then we made a special flange to fit the handle hole on the side door. The rigging, shown in Fig. 1, has an 8 to 1 ratio and in this way we get a 3-in. travel of the indicator with a 24-in. travel of the piston. This is a good rigging and can be used on a number of inclosed engines. A nice rigging that can be used on almost any engine is shown in Fig. 2. It consists of a lever *A*, a stand *B* and an eccentric *C*. The eccentric is fastened on the engine shaft *D* so that its maximum radius is in line with the connecting-rod at top center. The shaft actually should have a keyway to hold the eccentric."

Organization Chart, Union Gas and Electric Co.

Below is shown the power-house organization chart as it applies to the stations of the Union Gas and Electric Co., Cincinnati, Ohio.

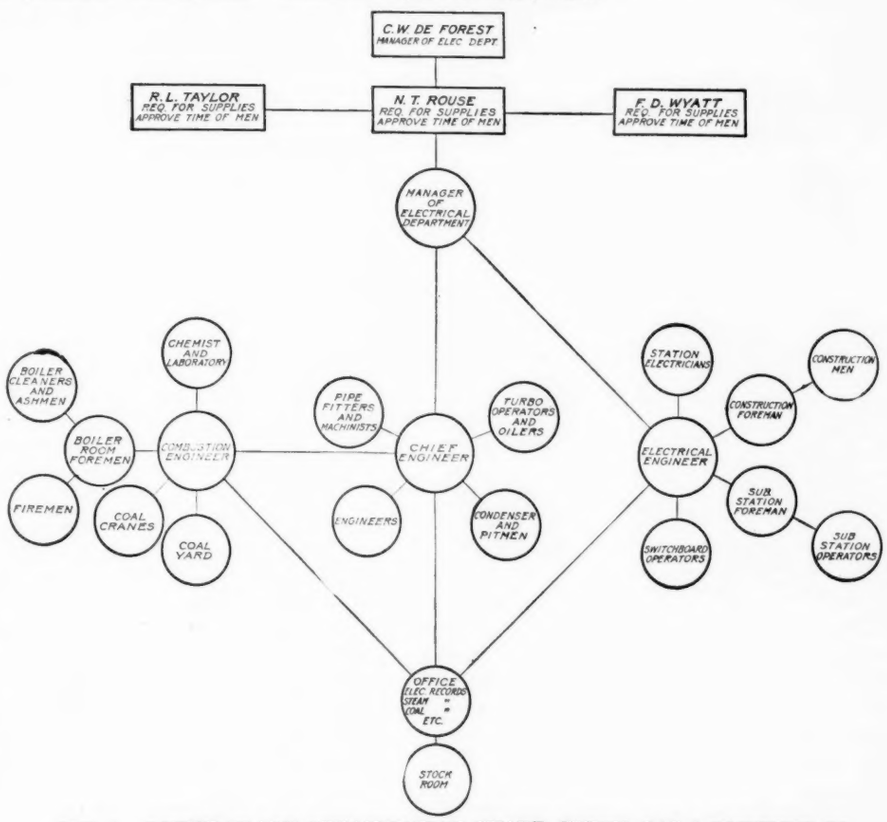


FIG. 1. POWER-PLANT ORGANIZATION CHART, UNION GAS & ELECTRIC CO.

The Electrical Study Course—Apparatus Required for Brake Tests on Motors

Describes various types of pulleys that may be used in connection with brake tests and the methods of keeping them cool. Also gives the construction of several different brakes that can be applied to the pulleys.

IT WAS shown in the previous lesson that it is necessary to provide means for limiting the temperature of a pulley that is used on a motor that is to be subjected to a brake test. The most usual method of accomplishing this is to introduce water into the interior of the pulley. To prevent the water from being thrown from the pulley it is constructed somewhat as shown in Fig. 1. The back is solid and the front is provided with a flange *b*. After the machine has been started, the water is poured into the pulley through the outside end. As soon as it strikes the interior, it is spread in a sheet over the inner periphery of the pulley by centrifugal force, and water may be added until it occupies a depth equal to the length of the flange. When the brake is applied, and the pulley rim thereby becomes heated, the water is evaporated and will finally all disappear. It is therefore necessary to replenish it from time to time.

When dealing with large machines, in which case the evaporation is great, the water may be led to the pulley through a pipe. In such instances a waste pipe may also be provided for taking off surplus water. The arrangement in Fig. 2 shows a large pulley that revolves in the direction of the arrow *A*. Water is led

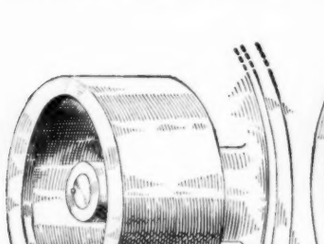


FIG. 1. SMALL WATER-COOLED BRAKE PULLEY

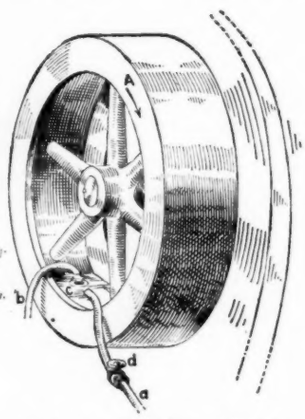


FIG. 2. LARGE WATER-COOLED BRAKE PULLEY

into the rim through the pipe *a* and is scooped up by the pipe *b*, which has its end flattened, as shown at *c*. The flow of water is regulated, by means of the valve *d*, not to exceed the capacity of the waste *b*. This method not only dispenses with the necessity of filling the rim by hand, but has the added advantage of keeping the pulley at a comparatively low temperature due to the fact that water is constantly flowing through it. When testing large machines, we thereby overcome the objectionable feature of liberating a large volume of steam that fills the room, which is attendant upon the method that relies upon evaporation. It is, however, applicable only to large-sized motors in which the friction of the pipes with the water would be a negligible quantity as compared with the other losses involved. It will be noticed that the construction differs somewhat from that shown in Fig. 1, in that an ordinary spoked wheel is used and that both rims are provided with flanges.

In addition to water-cooled types of pulleys, there are some that are air-cooled. One of these is shown in Fig. 3. It is provided with flanges *a* that radiate the heat generated. Holes *b* are drilled through the

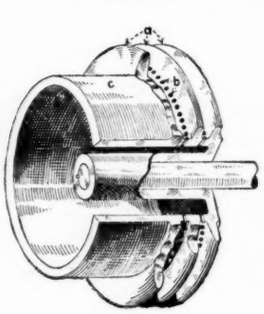


FIG. 3. AIR-COOLED BRAKE PULLEY

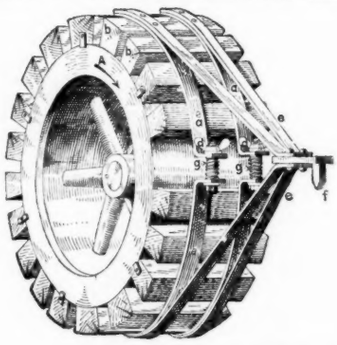


FIG. 4. PRONY BRAKE FOR LARGE MACHINE

rim of the pulley between the flanges. As the pulley revolves, air is forced through these holes at a considerable velocity, thus creating a rush of air past the flanges *a*, and thereby preventing the temperature from attaining a dangerous value. The brake is placed upon the portion *c* of the pulley.

The brakes that are used in connection with brake tests are of many different forms, but the object of all of them is to provide means for applying a friction load to the pulley of the motor and means for measuring the force exerted by the pulley in trying to drag the brake around with it. In Fig. 4 is shown a type, known as a prony brake, that is applicable to a large number of conditions. It consists of steel bands *a* to which are attached wooden blocks *b* and an arm *ee*. By tightening or loosening the nuts *d* the friction between the brake and the pulley can be adjusted. The springs *g* serve to separate the bands when the nuts *d* are loosened. The force acting to drag the brake around can be determined by placing a platform scale under the knife-edge *f* of the arm *e* and observing the pressure indicated upon it. It is understood that the pulley is revolving in the direction of the arrow *A*.

The foregoing is rather an expensive construction and many modifications of it are employed, particularly for smaller machines. One such modification is shown in Fig. 5. It consisted of a block of wood *a* that fits the pulley snugly and a piece of strong canvas belting *b* that is attached to the hangers *cc*. By means of the nut *d* the friction between the belt and the pulley can be regulated.

Another form of brake uses a canvas strap similar to the one just described, but dispenses with the block *a* and the arm *e* by using a construction such as that indicated in Fig. 6, in which *a* is a cross-bar supported from the floor by the uprights *bb*, *c* is a spring

balance and d a beam scale. As before, the tension of the strap is adjusted by means of the nut e, the dragging force being determined from the readings of the two scales, as is to be explained in a future lesson. The direction of rotation would be that indicated by the arrow A.

Frequently, the pulleys used for brake tests are provided with flanges as shown at a in Fig. 7, to prevent

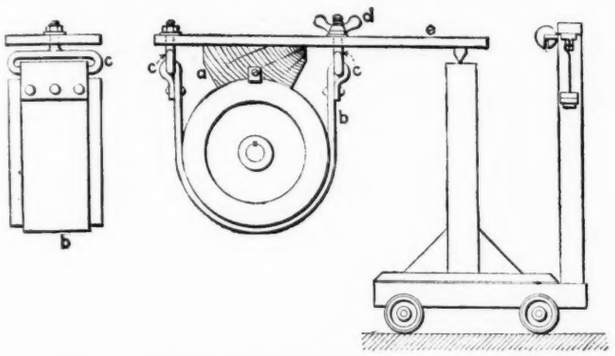


FIG. 5. PRONY BRAKE FOR SMALL MACHINES

the brake from slipping off the pulley. Side strips may be attached to the brake, as at a in Fig. 8, to accomplish the same purpose.

In the following lessons the theory applying to brake tests will be developed and the manner in which the various types of brakes are employed to secure the data required will be explained.

In the problem of the preceding lesson it was required to find the size of motor that it would be necessary to install to drive the pulley of Fig. 9 at 30 r.p.m., if its diameter is 18 in., and if the weights of W_1 and W_2 are 300 and 1500 lb. respectively. The problem is one that requires us to determine the num-

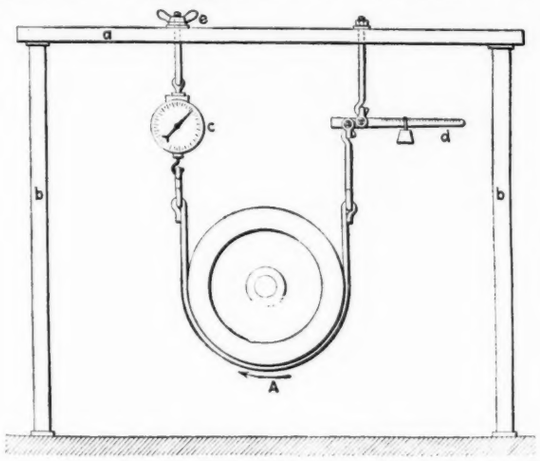


FIG. 6. BRAKE ON WHICH TWO SCALES ARE USED

ber of feet a given number of pounds must be raised per minute; that is, the number of foot-pounds per minute that the motor is required to develop. Since one horsepower represents 33,000 ft.-lb. per min., we divide the total number of foot-pounds per minute by 33,000 to find the horsepower the motor is called upon to furnish. Thus, if P be used to represent the power in foot-pounds per minute, we have, hp. $= \frac{P}{33,000}$. The number of foot-pounds per minute of the motor will be equal to the weight of W_2 minus that of W_1 multiplied by the number of feet through which W_2 is raised in one minute. That is, $P = (W_2 - W_1) \times L$, where L is the distance, in feet, through which W_2 is raised in one minute. The distance through which the weights are moved in one minute depends upon the speed of the pulley. In one revolution the cable supporting the weights would be moved a distance equal to the circumference of the pulley, provided there is no slip between the cable and the pulley. Thus, if l represent the distance moved through in one revolution, and D be the diameter of the pulley, we have $l = \pi D$. Substituting for D its value as given, namely 18

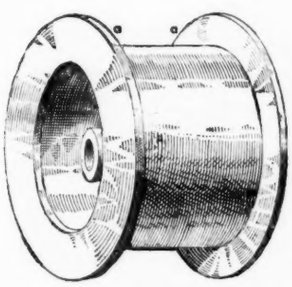


FIG. 7. FLANGED-TYPE BRAKE PULLEY

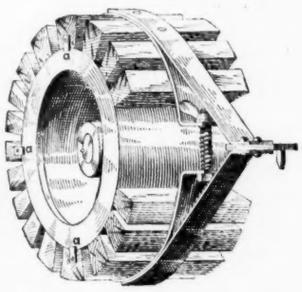


FIG. 8. PRONY BRAKE FOR MEDIUM-SIZED MACHINE

in., and for π its value (3.1416) gives, $l = 3.1416 \times 18 = 56.55$ in. Since the pulley makes 30 revolutions in one minute, the distance through which the weights are moved in one minute will be 30 times the distance they are moved through in one revolution, or $L = 30 \times l = 30 \times 56.55 = 1696.5$ in. To convert inches into feet we divide by 12, giving $L = \frac{1696.5}{12} = 141.4$ ft. Substituting in the expression for P, we have, $P = (W_2 - W_1) \times L = (1500 - 300) \times 141.4 = 169,700$ ft.-lb. per min., from which we get, hp. $= \frac{P}{33,000} = \frac{169,700}{33,000} = 5.14$. It would therefore require a 5-hp. motor to meet the conditions.

Fig. 10 represents an arm a keyed to a shaft b to which is also attached a pulley c. A strap d passes

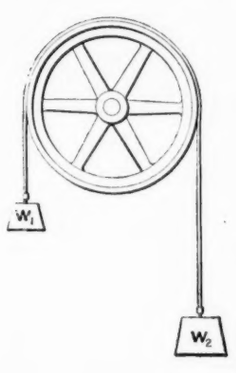


FIG. 9. TWO WEIGHTS SUPPORTED OVER A PULLEY

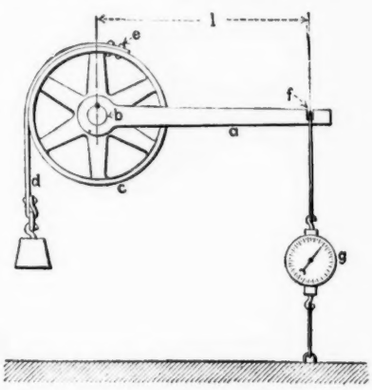


FIG. 10. BRAKE PROBLEM FOR FOLLOWING LESSON

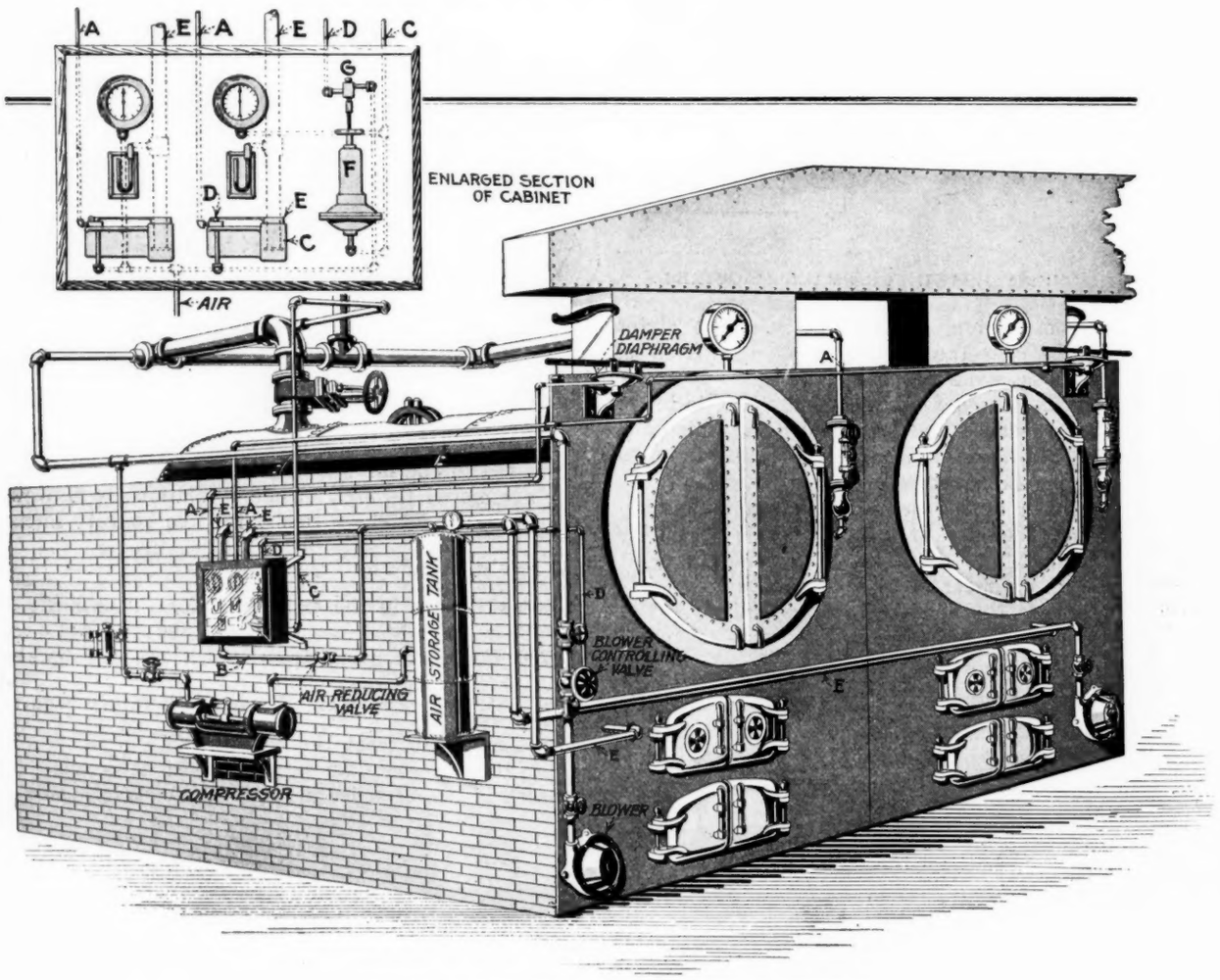
around the pulley and is fastened to it as indicated at c, and from it is suspended a weight W. Owing to the pull of the arm at f, the scale g indicated a weight of 10 lb. What must be the weight of W to produce this pull if the diameter of the pulley is 8 in. and the distance l is 2 ft.?

Oil-Seal Combustion Control

In stoker-fired boiler furnaces it is the practice to regulate the feed of the stoker and the speed of the forced-draft fan by means of the steam pressure. Thus, when the steam pressure increases the stoker and the fan speed is decreased, and as the steam pressure decreases the speed of the fan and stoker is increased. Another method has been adopted by the Vapor Vacuum Heating Co., Otis Building, Philadelphia, Penn., which operates on the principle that the gas pressure in the furnace of a boiler is the logical agent for determining the amount of draft to the chimney and the quantity of air to be passed through the fuel bed to support combustion. When the steam gage shows a drop in pressure, the supply of air passing through the fuel bed is increased, and this results in a higher rate of combustion until the steam pressure returns to normal. Referring to the illustration, the pipes *E* leading from the furnace to the oil seal *C* in the cabinet convey the gas pressure to the surface of oil contained in the seal, and as the gas pressure rises or falls, the level of the oil changes, thus moving the small float *E* up or down. This float in turn opens or closes the valve *D* by means of a lever which responds to the movements of the float, thus allowing compressed air to pass through the valve *D* to the diaphragm operating the boiler damper, connection being made by means of the pipes *A*. The position of the dampers is changed in proportion to the quantity and pressure of gases generated in the furnace on account of the increase or decrease in the rate of combustion.

Live steam from the main steam line operates the diaphragm *F*, and as the steam pressure changes, the diaphragm responds and opens or closes the valve *D*, through which compressed air from the air-storage tank passes to the diaphragm on the steam valve, which in turn controls the quantity of air supplied to the bed of fuel by whatever method is used for this particular purpose.

From the foregoing it will be seen that the movement of the waste gases to the chimney and the quantity of air supplied for combustion are taken care of individually; that is, the air for combustion is controlled by the steam pressure, and the position of the damper to the chimney by the pressure of the gases over the fire or in the combustion chamber. At the left of the illustration is shown an enlarged view of the cabinet, which contains, besides the apparatus already mentioned, a draft gage showing the pressure in the furnace and combustion chamber, a compressed-air gage, and a boiler-pressure gage. The piping and general arrangement of the system are shown in the large illustration.



PIPING OF THE OIL-SEAL COMBUSTION CONTROL

EDITORIALS

What Is the Most Satisfactory Hydrostatic Test Pressure for Boilers?

IN REPORTING to the Institute of Naval Architects on the work of the British Marine Engineering Design and Construction Committee, A. E. Seaton said: "It is concluded to be quite unnecessary now to test boilers by water to double the working pressure; in fact, there is the possibility that instead of such a proceeding being a source of safety, it will become a cause of damage to the structure, especially to the staunchness or tightness of the joints. The opinion has been expressed and strongly supported that the test pressure should no longer be any multiple of the working pressure, but rather it should be an added excess such as is provided in the rules of the British Admiralty and many foreign authorities. The committee would have been content with one hundred pounds margin over the working pressure as being sufficient for every purpose for which such a test is designed."

Notice he says, "would have been content." In deference to the views of the Board of Trade, the committee adopted the following rule:

> Hydraulic test pressure is to be fifty pounds in excess of one and one-half times the working pressure for all new boilers, but is not to exceed one and one-half times the working pressure for boilers which have been in use.

Does the committee express the opinion of many when it says a margin of one hundred pounds over the working pressure is sufficient? Whether or not one agrees with the committee, one must ask if a boiler should be a hundred pounds stronger than its working pressure or within this amount, or whether it should stand without revealing weakness a stress one and a half times as great as its working pressure whatever that pressure may be. There is a great difference. By using a multiple of the working pressure, the strain is proportional for all working pressures and all boilers, presuming the latter to have been built with the same factor of safety. This cannot be so if an excess of a specific amount is applied to all boilers.

According to the high-pressure boiler rulings of authorities in North America, which call for a hydrostatic test pressure of one and one-half times the working pressure (Massachusetts requires one and one-quarter times) this margin is overstepped when two hundred pounds is exceeded. For one hundred and fifty pounds the excess pressure called for is seventy-five pounds above the working pressure, or twenty-five pounds less than the one hundred pounds of Mr. Seaton's committee. For a working pressure of three hundred and fifty pounds the excess is one hundred and seventy-five pounds. But as the boilers are designed for the same factor of safety, the stress will bear the same relation to the elastic limit in both cases.

Mr. Seaton's assertion and the evident practice of the British Admiralty will surprise many in America. Likely it would be difficult to convince engineers on this side of the Atlantic that any hydrostatic-test pressure not causing a stress in proportion to the elastic limit would be acceptable. Nevertheless Mr. Seaton's qualifications and the traditions of the British Admiralty command consideration.

Is there a good reason to reduce the hydrostatic-test pressure on boilers which carry, say from two hundred pounds pressure up?

Carbon and Commutator Wear

ALTHOUGH a great deal of study has been given to the characteristics of carbon brushes, both by brush and by electric-machinery manufacturers, there is nevertheless a fruitful field for further investigation. The effects of such characteristics as contact drop under commutating conditions, sparking voltage, thermal conductivity and also refractory properties under various conditions are all open questions. This is quite evident from the letter, "Carbon and Commutator Wear," by R. E. Hellmund, on page 868 of this issue, referring to the influence of temperature on the carrying capacity of brushes, and taking issue with a communication by Warren C. Kalb, appearing in *Power* of March eighteenth, in which the statement is made that brush wear is influenced largely by the temperature at the contact face. It would seem that the difference in opinion here noted results from a consideration of temperature variation over ranges that are videly separated. It is undoubtedly true that within limits increased temperature has very little influence on brush wear. However, it is understood that the temperatures referred to by Mr. Kalb as causing appreciable brush wear were high enough to induce glowing at the brush face or at least to create momentary incandescence at certain points on the brush contact. Until such temperatures as this are reached, it is probable that variations in temperature influence brush wear to a negligible extent. For this reason variations in temperature produced by external means would have little effect unless they were carried high enough to cause glowing of the carbon.

It is quite possible that arcing due to either mechanical vibration or high sparking voltages may exist without serious wear provided the interval during which this arcing exists at a given spot is very brief. In such case the temperature of the surrounding carbon would not be brought up to a point at which any pronounced disintegration would take place. Passing a high current density through the brush while this condition exists, might bring up the temperature over the entire contact face near enough to the destructive point so that the added effect of the arcing, even for a very brief period, would result in disintegration.

Mr. Hellmund brings out another factor which undoubtedly has a pronounced influence on brush and commutator wear. This is the ionization of the carbon as well as the copper particles at the contact of the brush on the commutator. This phenomenon has sometimes been spoken of as an electrolytic action. That such a condition exists is evident from the fact that a positive brush will in nearly all cases have a different contact drop from the negative brush of the same

material on the same commutator. The effect of the brush polarity on the commutator surface is also different, as can be seen where positive and negative brushes bear on different paths on the commutator.

The instance cited in which fifteen to twenty volts sparking voltage was impressed across a brush contact without injury in the absence of load current might be explained by two conditions. Either a very brief com mutation interval, allowing insufficient time for appreciable temperature rise at any given spot on the brush face, or the absence of ionization due to there being no load current through the contact.

Mr. Hellmund has raised a point of vital interest to brush manufacturers as well as to manufacturers of dynamo-electric machinery. It would be interesting to learn the full details of his experiments and of any other research work that has been conducted along these lines.

Prospects for a Power Survey

WITH the opening of the Sixty-sixth Congress the movement to obtain appropriations for a power survey of the United States is again under way. The estimates of appropriation presented by Secretary Lane to the last Congress have been renewed and are now before the Appropriations Committee of the House. These appropriations, which, owing to the filibuster at the close of the last session, failed of passage, will, if made, permit the Geological Survey to expend two hundred and fifty thousand dollars in studies of power supply during the coming fiscal year.

Of this amount fifty thousand dollars is to be used in a general engineering and statistical survey of the power resources of the United States. Present and possible sources of power will be surveyed and detailed maps prepared showing the location of existing power plants and transmission systems. Undeveloped water powers will be more critically studied and estimates of this resource will be revised. A new service is planned with a view of bringing together manufacturers desiring to establish new plants and concerns having surplus power available for use. Monthly and annual reports of the progress of power production are also contemplated as a barometer of electrical development

The balance of the appropriation will be used for an intensive survey of power conditions along the North Atlantic Seaboard. It is upon this item that Secretary Lane is dependent for means to investigate the possibility and usefulness of his super-power plan for the interconnection of the power centers of the Atlantic Coast, thus making possible more complete utilization of water power and the electrification of trunk-line railroads. If this appropriation is authorized, the Secretary proposes to enlist the coöperation of the electrical industry in a careful economic and engineering investigation of the future power requirements of this region and of the best means of supplying its needs, taking into consideration the most efficient possible use of natural resources.

The Secretary believes, that the solution of the problem of power supply is just as vital to the future welfare of the nation as are the problems of transportation or crop production, for the investigation of which millions are expended annually. Indeed this belief was substantiated by many events of the past two years. At the present time Congress makes no appropriations whatever for the study of power resources, and it is the opinion of many operators that the industry has not heretofore received the public support that its national importance justifies. If the appropriations requested by Secretary Lane are granted by Congress, they will form the basis for work that not only will be of great assistance to the public, but will bring about a realization of the key position of the power business in relation to other industries.

Handling Ice at Holtwood Hydro-Electric Station

OUR many readers in hydro-electric plants will find much to interest them in the article on handling ice situations at Holtwood, printed elsewhere in this issue. Fortunate are the crews of stations where there are no ice troubles, but particularly fortunate are those in stations where there is no ice to give trouble. In the history of Holtwood, which is on the Susquehanna River a short distance up stream from Perryville, Md., there has been but one total interruption because of ice, and this happened, as shown by the ice-trouble record in the article, in 1912, when the station was new and in the first winter of its operation.

But to achieve the splendid record of freedom from ice troubles the engineers at Holtwood have been busy; it has required considerable study, preparation and organization. What is done and how is told in the article.

Of course it is frazil ice that gives the most trouble at Holtwood, as it does elsewhere. This is a very trying trouble-maker. It is Old Dame Nature herself who forms it, and man might as well attempt defiance of gravitation's laws as to try to prevent her filling a body of water with these fine crystals. And once formed, once into the screenhouse and into the turbines without preparations for its visit, the generators cease to function, particularly if the greater part of the turbine is submerged, as nearly all are at Holtwood.

But the crew there is extraordinarily vigilant. As frazil ice forms with astounding suddenness, with a comparatively minute drop in temperature, and on a rising peak load at Holtwood, the river temperature is closely watched, recorded and reported to the operator. Steam or electricity is not used to heat the water that fraction of a degree needed to avoid or dissolve frazil ice. The screens and gates are opened to let the crystal-impregnated water rush through into the tailrace. Steam is used to thaw away the ice should a machine become blocked with it. How Holtwood handles its ice is a valuable contribution to the literature on the subject.

Chief engineers of the textile mills at New Bedford, Massachusetts, struck on May nineteenth for a wage increase and caused a complete shutdown of plants employing thirty thousand operatives. The mill firemen are supporting the engineers in their demand for forty-two dollars weekly for engineers in charge and thirty-seven dollars weekly for operating engineers with time and one-half for work in excess of forty-eight hours weekly. Well, it costs as much in proportion for an engineer to live as it does for the man getting a fat salary.

The duty of every chief engineer is to devote attention to educating the personnel of the plant to the proper and most advantageous use of the equipment to obtain the best results from its use.

Correspondence

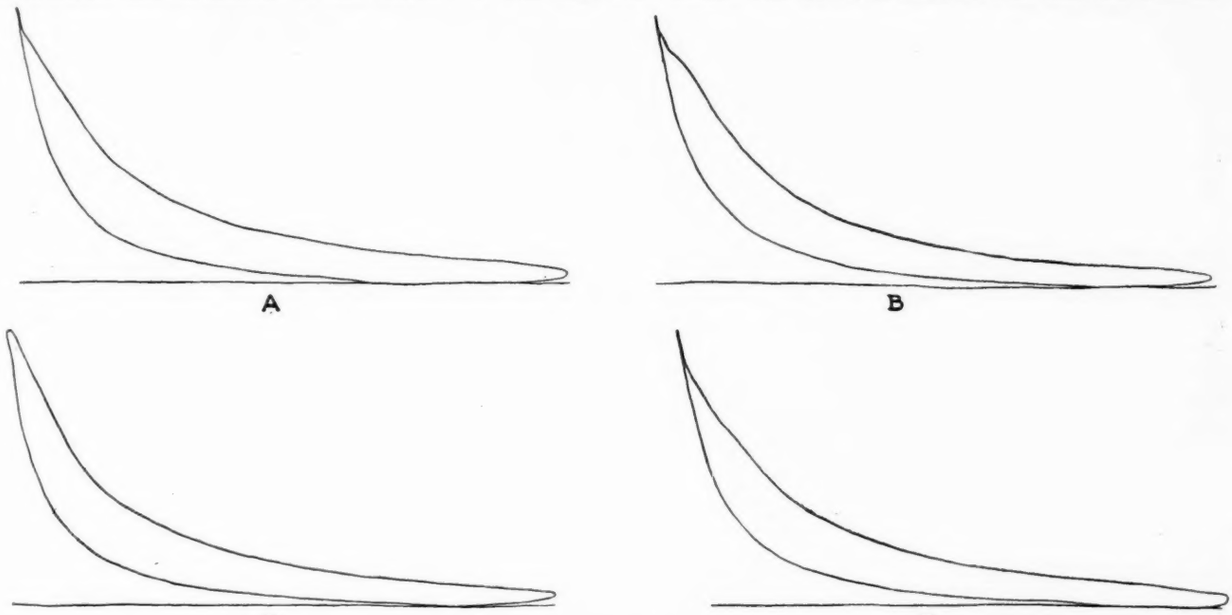
Curious Explosions in a 750-Horsepower Diesel Engine

Diesel engines are not supposed to be preigniting, but we had one instance where this was the case. Upon starting up a new 750-hp. unit, curious noises accompanied its operation and trouble was experienced due to faulty valve-setting and leaky valves. The noises were eliminated with the exception of one peculiar cracking sound that occurred at times during the noon shutdown period or after stopping the engine at night. This trouble was brought to the attention of the makers, but nothing was found mechanically wrong, and by some it was thought that the noise was caused by the contraction and expansion of the metal. It was also observed once shortly before starting time, and it was puzzling, to say the least.

One noon, about two minutes after stopping the engine, a bang occurred. We were certain that the fuel valves and the other valves were in good working order, the engine having been working smoothly and with a clear and colorless exhaust. The circulating water was not cut off, as it was our custom to allow it to circulate during the shutdown period. We went up on the operating platform and found a little smoke issuing from the air-valve pipe of the fourth cylinder from the flywheel side of the engine. This showed that oil gas was forming and that explosions in a mild form were occurring during the shutdown period.

Then we began to investigate as to why gas should explode when the compression-breaking lever had been raised, and also to ascertain if the lever was in working order. The exhaust valve was closed, and in about two minutes after the first explosion another followed, flames issued from the air-valve pipe, and the engine was turned over backward one revolution. Although the second explosion was a heavy one, the engine was not damaged.

We finally came to the conclusion that the explosions were due to the ignition of gas from oil, and we were puzzled as to where the oil was coming from, as the fuel and pump valves were in the best of condition. Then it was recalled that the manufacturers had supplied a glass drip cup on the exhaust- and air-valve cages and had advised us to lubricate the exhaust-valve spindles with kerosene oil. I am of the opinion that this oil collected in the poppet-valve cages and did not pass the valve when the engine was running; but when the engine was slowly coming to rest and the exhaust-valve lever was held up for breaking the compression to avoid turning the engine backward, the collected oil passed the exhaust-valve opening into the cylinder, and then the exhaust-valve closing, the gas from the kerosene exploded due either to carbon deposits or to a hot piston.



DIAGRAMS WITH DIFFERENT POINTS OF IGNITION

The accompanying indicator diagrams were taken from this same engine, and I would like to know why the diagrams *A*, *B* and *D* show different points of ignition from diagram *C*, when the fuel-valve gages of all cylinders were made equal in stopping time. It has been observed that, when running, the gages on the valves did not remain the same—that is, reading from twelve to fifteen thousandths more—and also that all did not increase in the same proportion. These diagrams were all taken from the same cylinder without making any alterations. Who can give an explanation as to the difference in the point of ignition?

P. P. TALATY.

Ahmedabad, British India.

An Emergency Engine Repair

The engineer of a certain factory was such a thoroughly competent man, so steady and reliable, and had been there so long that the manager had forgotten that anything could go wrong with a steam-power plant; and as this engineer never seemed to have anything to do, he had come to be regarded somewhat as an expensive luxury.

On one occasion when it was necessary for him to be away for several days, instead of a competent man being put in his place, as the engineer recommended, the fireman was put in charge of the engine, and consequently about the middle of the afternoon of the fourth day an S. O. S. call came from this factory to the machine shop where I was employed.

On arriving at the factory I found them pouring oil on the engine's main pillow block, which was so hot that the babbitt had commenced to run. This factory was so far behind with its orders that it could not be stopped for repairs, so we loosened up the quarter brasses and turned a stream of water on the bearing, hoping to cool it down enough to enable the engine to run until the next Saturday night; but it was too far gone. I therefore decided to babbitt the bearing that night.

On my asking for two of the boys from the shop for helpers, the manager of the factory objected on account of the expense, saying that he would give me two of the factory laborers. I strenuously protested, as they, knowing nothing of such work, would be of little use to me. However, I had to take them.

Closing time found everything in readiness. The outboard end of the shaft could be jacked up, but conditions were such that the crank end had to be raised with a 3-ton tackle. I chipped the babbitt out in a hurry and, allowing the shaft to rest in the outboard bearing, set the crank end a little high above the center (about $\frac{1}{16}$ in.), so that after some months of wear it would be worn down to the center.

Having the shaft set for height, and not having time to take out the piston and crosshead to put a line through in the usual way, I took off the head-end cylinder head and with a long straight-edge lightly clamped against the back end of the cylinder, and about central as to height and level, the shaft was set square by tramming from the straight-edge to the crankshaft, improvising an excellent tram by driving a round-headed nail in each end of a stick of the right length and about one inch square, first calipering the shaft to make sure that it was parallel (See Fig. 1). The bottom of the box was then poured, the shaft lifted out and the surplus babbitt chipped off. Then the shaft was replaced and tested for alignment. The quarter brasses were poured and fitted, the cap being poured last.

While I was replacing the back cylinder-head and connecting-rod, I had the helpers take down the tackle used in lifting the shaft, but being sleepy and not used to such work, they let the tackle fall, and it struck the governor belt pulley and broke a big piece out of it. It was pure luck that it did not hit the eccentric.

The factory must start at 7 o'clock and it was then about 5:30. Some pieces of tin were fitted to the pulley and babbitt was poured to fill the vacancy where the piece was broken out, Fig. 2. I then built up a wooden frame to serve as a tool rest and, using a carpenter's chisel as a hand tool, the engine was run on the throttle while I turned the babbitt down and smoothed it up true. The engine was stopped, the governor belt was put on and we started up again at just five minutes before seven.

M. L. LOWREY.

Livermore, Calif.

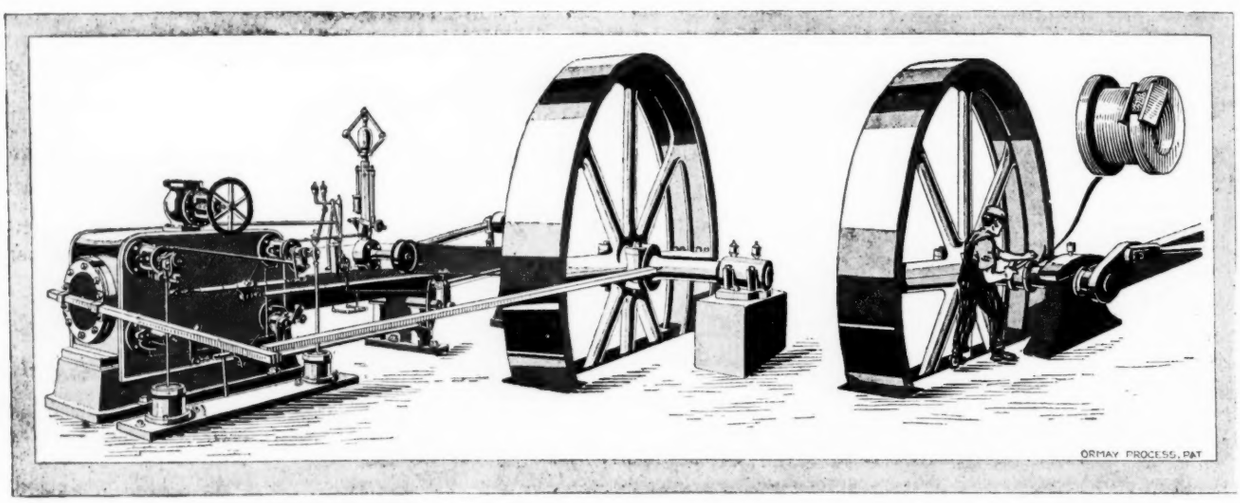


FIG. 1. HOW THE SHAFT OF THE ENGINE WAS ALIGNED

FIG. 2. SMOOTHING THE GOVERNOR BELT PULLEY

What Makes the Exciter's Voltage Slow to Build Up?

Referring to C. S. Harrison's letter, "What Makes the Exciter's Voltage Slow to Build Up?" in *Power* of Apr. 1, it may be that the series- and shunt-field windings are connected in opposition. This would make the exciter sluggish in its response to variations in the load. It is possible that the field excitation of the exciter may be weak due to a poor connection somewhere in the field circuit. I would advise testing the voltage drop across each field coil. Poor brush contact would cause the machine to be slow to build up, as would also brushes of too high a resistance. However, brush trouble generally manifests itself by considerable sparking at the commutator.

L. A. COLE.

Columbus, Ohio.

Difference in Heating Systems

In the illustration Fig. 1 shows the return piping of the heating system in one plant. This system was supplied with exhaust steam supplemented by live steam brought to atmospheric pressure through a reducing valve. The radiator valves were thermostatically controlled. A gage at the radiators showed about 4 in. vacuum, while the pump gage showed 10

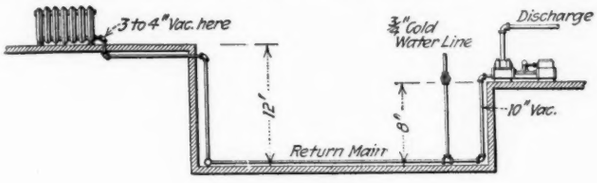


Fig. 1

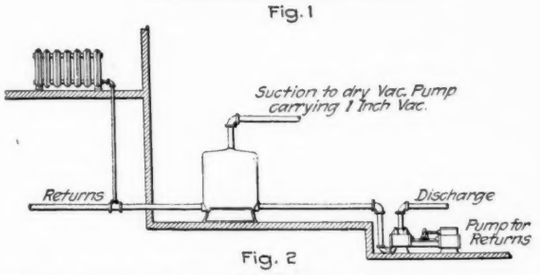


Fig. 2

FIGS. 1 AND 2. PIPING OF TWO HEATING SYSTEMS

in., probably on account of having to lift the returns from the main, which was 8 ft. below the pump. A ¾-in. pipe connection for cold water had to be kept wide open, for when no cold water was used the pump would become steambound and could not lift the water from the return main. This is the only system I ever saw arranged in this way, and it looks to me like a poor job.

Another heating system that I had charge of was arranged as shown in Fig. 2. This one took much less steam, using steam at atmospheric pressure, and a vacuum of one inch was carried on the returns.

I would be pleased to have this subject discussed and learn the opinion of other readers.

Chicago, Ill. L. B. SHIELDS.

Graphite for Reducing Slag Formation on Exterior of Boiler Tubes

A statement appearing on page 340, of the Mar. 4 issue of *Power*, in an article reporting the meeting of Illinois Chief Engineers, deserves having attention focused upon it. This statement reads: "Formation of slag on the lower tubes of a water-tube boiler has been prevented by the application of graphite and the use of a hand lance in addition to the mechanical blower."

This is interesting, because it is the first pass of a boiler that does the most work, hence interference with heat transfer here interferes most with boiler efficiency. It is the formation of slag on the first few rows of boiler tubes that has so far caused one of the most difficult problems with which the manufacturer of mechanical soot blowers has had to deal, and it is not yet solved. If the use of graphite is a solution or even a partial solution, it is to be highly advocated, especially in installations using mechanical draft, operating with settings insufficiently high, and at high ratings; because it is especially in such cases that flue-gas dust and slag are most likely to cause trouble. The use of low-grade fuels with high ash content, necessitating high draft intensities to maintain capacities, has tended to make the slag trouble the more serious.

Graphite is a combustible. It oxidizes in an oxidizing atmosphere. Furnace gases are oxidizing. With a temperature of 2400 deg. F. and higher over the fuel bed, with a temperature of 1700 deg. F. and thereabouts around the first row of tubes, the questions are: Will graphite stand up for any length of time? In applying graphite what vehicle is employed to withstand these high temperatures? How long does a coating of graphite last under these circumstances? Is the application practical so far as the heat resistivity of graphite and its vehicle is concerned?

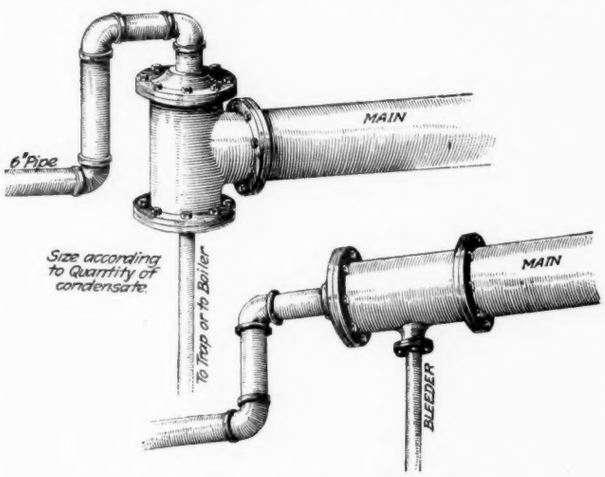
And another pertinent question would be: Even if graphite and the vehicle making it into a paint have the requisite heat resistivity, which means a certain life under actual operating conditions, how is this graphite paint to be applied? The first few rows of boiler tubes are not accessible when once installed, and difficulty of applying the graphite would be a serious detriment to its use.

If the use of graphite for preventing furnace slag from forming across the outside of the first few rows of tubes, obstructing draft, interfering with boiler efficiency and introducing the possibility of tube troubles, is as effective as it is for preventing the adherence of scale to the inside of the tubes, its application is certainly worth advertising and encouraging. What is the experience of operating engineers? What are the criticisms of the foregoing reasoning? The writer hopes he is wrong. S. B. WILKINSON.

Chicago, Ill.

Changes in Header Piping

If I had my way, I would never drain a main as shown by Mr. Wakeman, on page 327 of the Mar. 4



TWO METHODS OF PIPING BLEEDER PIPE

issue. I would deem such connection insecure under any pressure. It would be better to put in a flanged tee with the run vertical or horizontal according to the available space, as shown by accompanying illustrations. This would admit of making a proper connection of the bleeder pipe to the tee instead of screwing it into a threaded hole in the pipe. A. DOLPHIN.

Jamaica, L. I.

Easily Made Ferrules

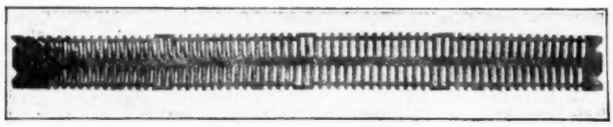
The thimble ferrule described by William H. Watson on page 741 of the Apr. 13 issue of *Power*, will answer the purpose on a handle for a small tool, but old thimbles are a rather scarce article around a power plant.

For years engineers have been in the habit of using the end caps from burned-out inclosed fuses for ferrules. Usually, there are different-sized fuses in plants, the caps on the 15-ampere 250-volt ones being ½ in. in diameter, gradually increasing in diameter as the amperage increases. The 200-ampere 250-volt fuses have caps 1½ in. in diameter, and the weights of the caps are just about right for the different-sized ferrules.

Portsmouth. Ont., Canada. JAMES E. NOBLE.

Grate Bar Used Nineteen Years

The illustration shows a grate bar that I have used for nineteen years. It may be an easy matter to find



GRATE-BAR AFTER 19 YEARS OF SERVICE

bars that have been in use longer, but not of this type, and they may not be so well preserved.

New Haven, Conn. W. H. WAKEMAN.

Carbon and Commutator Wear

Referring to the discussion by Warren C. Kalb on "Carbon and Commutator Wear" in the Mar. 18 issue of *Power* and my previous letter in the Feb. 4 issue, I would like to make a few additional remarks. It is to be expected that, as mentioned by Mr. Kalb, brush wear is affected by a number of factors outside of current density, sparking voltage and peripheral speed. It is, of course, desirable that whatever such factors may be, their influence should be studied.

One of the factors mentioned by Mr. Kalb is temperature. While no doubt temperature has some influence, I am inclined to think that Mr. Kalb attributes too much importance to this point. Tests made on certain carbons indicate that within limits increased temperature had very little influence on the wear. The temperature was varied in this case by external means independent of current density, sparking voltages, etc. Again, other tests indicated that even if the temperatures were carried rather high by means of high current densities, the wear was influenced but slightly as long as there was no arcing. Further, it was found that quite appreciable arcing caused either by mechanical vibration or by high sparking voltages resulted in very little wear as long as the current densities were low. Considerable wear was obtained only with a combination of appreciable arcing and appreciable current densities, although the temperatures were lower than in some of the other tests giving small wear. It seems, therefore, that the wear is not simply a question of temperature, but more due to the arcing and the amount of ionization at the brush which, in turn, is, of course, influenced by local temperatures, current densities, etc., to a certain extent.

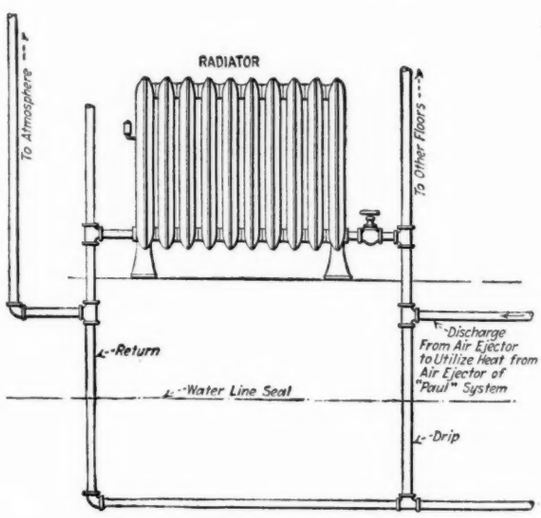
Since Mr. Kalb questions my statement regarding permissible sparking voltages of 15 to 20 volts across the brush, I wish to say that extended tests with such voltages and without load currents showed carbon wear amounting to only a small percentage of the wear obtained with the same carbons in actual service; that is with smaller sparking voltages and rather high current densities. The arcing voltage in the tests was not neutralized, but actually existed under the brush. The results were as surprising to me as they probably were to Mr. Kalb and convinced me more than ever that a lot of research work is needed along this line. Whatever carbons stand the highest current densities together with the greatest amount of sparking should certainly find a wide field of application. While commutating poles have eliminated sparking to a large extent, there are, in actual practice, still a lot of almost unavoidable causes for sparking. It is therefore best to realize this and develop carbons that stand up fairly well under these conditions. R. E. HELLMUND.

East Pittsburgh, Penn.

Utilizing Heat from Ejector Exhaust

In buildings equipped with the "Paul" system in which a vacuum is carried on the air line from the radiators, the vacuum is usually produced by means of a small steam ejector. Considerable heat is carried off by this ejector as an inspection of the exhaust pipe from it will show.

To utilize this waste heat a connection can be made to radiators supplying heat to a hall or stairway with the piping so arranged that these radiators cannot be shut off. Provision must also be made for separating the air from the water in the return piping. These radiators must be two-pipe, equipped with inlet



PIPING OF RADIATOR

and outlet piping so that the mixed steam and air can sweep through them. The illustration is intended to show the application of this method to a two-pipe system with a wet return.

Another way to utilize the heat from the ejector is to discharge the exhaust into a return tank several inches below the water line, thus imparting the heat to the water in the tank, the air escaping at the open vent. The return tank in one case is an open one into which the vacuum pumps discharge. W. T. MEINZER.

Brooklyn, N. Y.

Inquiries of General Interest

Short-Stroking Pump Uses More Steam—Does a steam pump use more or less steam when it short-strokes? M. C.

When a direct steam pump short-strokes, there is less water pumped and less steam used per stroke; but more steam is used in proportion to the length of stroke and the amount of water pumped per stroke, because there is a larger proportion of clearance space and a larger waste of steam in the steam cylinder.

Precautions Against Sticking of Safety Valve—What is the best way to guard against the sticking of a safety valve? W. R.

To know that the valve parts are clear, the valve should be raised by hand at least once in a five-hour run, and the pressure in the boiler should be raised to the blowing point at least once each day to observe that the valve blows at the proper pressure.

Size of Water-Column Connections—What size of pipe should be used to connect up a water column of a horizontal return-tubular boiler? R. K.

The minimum size of pipes and connections used should be 1 in. For a power boiler the water connection to the water column should be of brass and made up with plugged cross-fittings to facilitate cleaning and be fitted with a drain cock or valve not less than ¾ in., with suitable point of discharge for blowing out the connection.

Greater Economy of Four-Valve Engines—Why are four-valve engines more economical than single-valve engines? W. N. C.

Single valves are more likely to be wasteful from leakage of live steam direct to the exhaust and are provided with longer steam passages with more waste cylinder spaces than necessary for four-valve engines. In addition four-valve engines are capable of such design of valve gear as to obtain independent adjustment and operation of admission and exhaust for each end of the cylinder with the most desirable distribution of steam.

Equalizing the Load on Direct-Current Generators—We have two motor-generator sets, each consisting of a 2200-volt synchronous motor driving a 275-volt direct-current compound-wound interpole generator. One of the sets is 150-kw. capacity and the other 200-kw. capacity. The machines operate in parallel and are connected to the switchboard with the same size cables. The conductors connecting the 200-kw. machine to the busbars are about twice as long as those on the 150-kw. unit. Why does the 150-kw. unit take more than its share of the load when the machines are connected in parallel? Is it on account of the shorter connection between the generator and the switchboard on the 150-kw. unit? C. A. M.

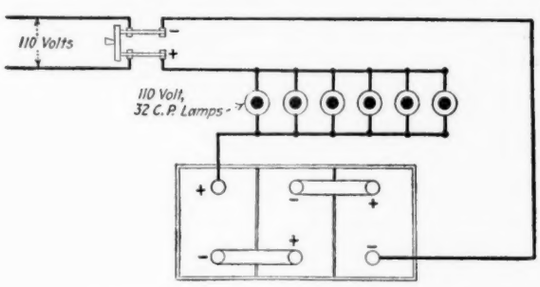
There are a number of causes that would make the 150-kw. machine take more than its share of the load, one of them being the difference in the length of conductors connecting the machines to the switchboard. If the machines had been located so the longest connections would have come on the smaller machine, no doubt it would have improved conditions. If the characteristics of the two machines are identical, then the cross-section of the conductors running from the large machine to the switchboard should be more than 100 per cent. greater than those on the small machine. It may be possible to improve conditions by placing a thin german-silver or iron washer under the equalizer lugs of the small machine, so as to increase the resistance of the equalizer connection.

Increasing the resistance of the compounding shunt on the large machine by reducing its cross-section, or decreasing the resistance of the shunt on the small machine by increasing its cross-section, should improve conditions. Probably the compounding shunt on the 200-kw. machine is of a lower resistance than that on the 150-kw. unit, and by interchanging the shunt it may be possible to accomplish the desired results. Shifting the brushes on the two machines may be tried. Moving them backward on the large machine will tend to give this machine a rising-voltage characteristic, while shifting them forward on the small machine will tend to give this machine a drooping-voltage characteristic. This will tend to make the 200-kw. unit take more of the load and the 150-kw unit take less. However, if the commutating zones are narrow on the machines, it may not be possible to shift the brushes without causing severe sparking.

Bringing the main polepiece closer to the armature on the large machine by placing iron shims on back of them may bring about an improvement. However, care must be exercised in doing this, because shims improperly placed would increase the reluctance of the magnetic path and have an effect just opposite to what was desired. It is doubtful if a satisfactory adjustment can be obtained by any one of the foregoing suggestions alone, but will have to be accomplished by a combination of them by applying the cut-and-try method.

Connections for Charging Storage Batteries—I would like to know the arrangement of 32-candlepower carbon lamps necessary to charge a three-cell automobile storage battery from a 110-volt direct-current circuit. J. H. H.

The diagram shows the connections for charging a small three-cell storage battery from a 110-volt circuit through a lamp bank. Care must be taken to get the positive



LAMPS IN SERIES WITH BATTERY

terminal of the circuit connected to the positive terminal of the battery. When the connections are made properly, the lamps will be giving a lower candlepower than when connected directly across the circuit. About six 32-candlepower or twelve 16-candlepower carbon lamps are required. Of course the number of lamps will depend upon the size of the battery.

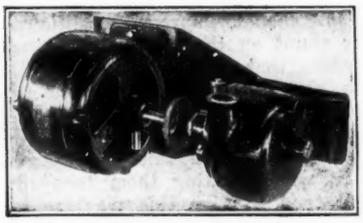
Eccentric Form of Crank—For operating a valve gear, when and why is an eccentric used in preference to a crank? W. D.

An eccentric is in fact a crankpin whose diameter is large enough to include the crank arm and crankshaft. When a reciprocating motion is to be obtained from a shaft and the crank must be placed between the ends of the shaft, the eccentric form must be used to avoid cutting the shaft to make room for the crank. An eccentric form of crank is preferable when it is desirable to obtain the smoother motion and greater strength of an enlarged crankpin and also greater compactness of design suitable for varying the angular position of the crank on the shaft.

Condensed-Clipping Index of Equipment

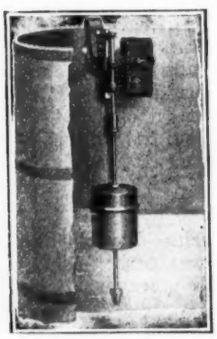
Clip, paste on 3 x 5-in. cards and file as desired

Pump, "Fulflo," Motor-Driven
Fulflo Pump Co., Blanchester, Ohio
"Power," Mar. 25, 1919



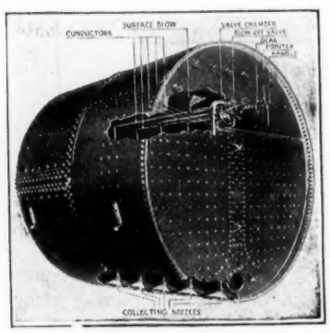
This pump is built in ⅜, ¾, 1 and 1¼-in. sizes arranged for either floor or wall mounting, and is equipped with ¼, ½, ¾ and 1-hp. motors respectively. Capacity of machines at 27 r.p.m. is 21 gal. per min. with an 11-ft. head, 20 gal. per min. with a 12½-ft. head and 11 gal. per min. with a 24-ft. head. Pump is of the centrifugal type, having intake and outlet located at the top. The impeller is of the semi-inclosed type and is supported by a bearing at either end of the impeller shaft.

Switch, Blackburn-Smith Inclosed
Blackburn-Smith Corporation, 105 West 40th St., New York City.
"Power," Mar. 18, 1919



Switch is of the single-pole, double-brake type designed for use with tanks, to regulate water level between high and low limits. Regulation is obtained by a float operating the switch, which in turn actuates a solenoid controlling mechanical or other electrical devices.

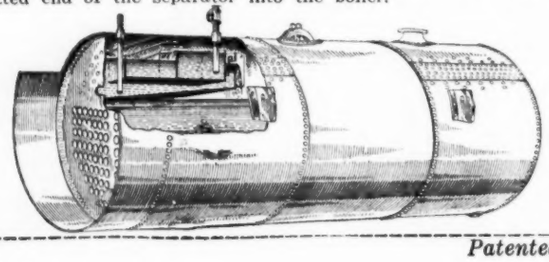
Cleaner, Geyser Boiler
Geyser Boiler Appliance Co., Detroit, Mich.
"Power," Mar. 4, 1919



This system consists of a number of connecting nozzles attached to pipes so as to distribute the nozzles along the bottom of the boiler shell of the Scotch-marine type. Nozzles are piped to a valve chamber that has three holes, one at each side and one at the top. A main blowoff valve is provided, and when turning the valve handle to, say, No. 1 on the dial plate, communication is opened between No. 1 connecting nozzle and the main blowoff pipe, thus blowing out the sediment in the vicinity of the nozzle. This operation is repeated by moving the valve until a complete revolution is made.

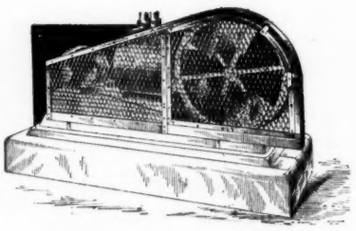
Boiler, Parker Double-Service
Thomas T. Parker, Brooklyn, N. Y.
"Power," Apr. 29, 1919

This boiler contains a device for separating scale-forming solids, mud, oil and other foreign matter. The apparatus consists of a live-steam feed-water purifier located in a horizontal fire-tube boiler and having two troughs. Feed water enters the first trough and, overflowing to the second, comes in contact with the live steam. Water flows from the second trough to the body of the purifier and, passing under a baffle plate, flows through a slotted end of the separator into the boiler.



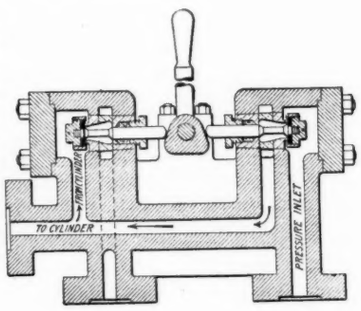
Guard, Steelcrete Machine
Expanded Metal Engineering Co., 8 West 40th St., New York City
"Power," Mar. 25, 1919

Steelcrete mesh machine guard is made of expanded metal, steel plate being cut and pulled out into a fabric of diamond-shape meshes, the diamonds being joined at their "bridges" by a short section of the unsheared plate. The sheets are attached and fitted to angle-iron frames by means of bolts, rivets or spot-welding. The mesh does not loosen up or sag, neither does it disintegrate in case one or more strands are fractured.



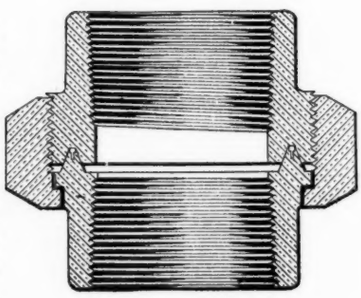
Valve, Hydraulic Operating.
Vance-Vetter Co., Pittsburgh, Penn.
"Power," Mar. 18, 1919

This hydraulic operating valve is made with flat disks that are easily renewed without disconnecting the valve or piping. The valves are operated by a cam movement, and each valve has a positive stop for open, flow and closed positions, and they cannot creep. When the handle is released to the center position, it centers and closes the valve automatically. The valve is designed for pressures up to 3000 lb. per square inch.



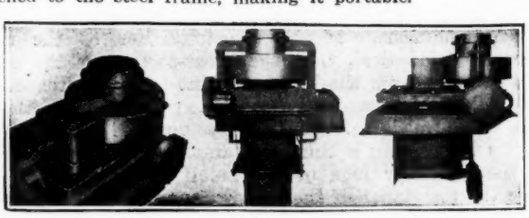
Union, Edward Gasketless Double-Tight
Edward Valve and Manufacturing Co., 72 West Adams St., Chicago, Ill.
"Power," Feb. 25, 1919

In this union the contact joint is made with a grooved V-shaped face, and the other is made with a split tongue. The faces of the tongue and groove are made with about two degrees difference of angle, and the joint is made at the narrow part of the V-groove, thus giving a somewhat flexible joint. No gasket is used. This construction gives two separate independent contacts of the split tongue in the groove.



Scale, Reliance Automatic Coal
James A. Brady Foundry Co., Chicago, Ill.
"Power," Apr. 8, 1919

The scale is designed for the continuous weighing of coal and is said to be accurate within one per cent. It is of all cast-iron construction and has a straight-sided hopper. Hardened-steel knife-edges are housed in a cast-iron box with felt washer to exclude dust. The ratio of the two arms of the balanced lever is four to one. The operating shaft is inclosed in a dust-proof case and is carried on ball bearings. If desired, flange wheels are attached to the steel frame, making it portable.



Patented Aug. 20, 1918

Refrigerating Engineers Approve Tentative Safety Code

HELD at Hotel Sinton, Cincinnati, May 19-21, the sixth Western meeting of the American Society of Refrigerating Engineers was a decided success. The outstanding feature of the convention was the adoption as it stood of the Tentative Code for the Regulation of Refrigeration Machines and Refrigerants, which has been in the course of preparation for the last two years by a committee of the society. The plan was to prepare a code that would be authentic and right for the guidance of municipal or state legislators and to insure uniformity in the regulations. On this account it was made as simple as possible, giving protection with a minimum amount of trouble and equipment. The code applies to every refrigerating machine employing ammonia, carbon dioxide, ethyl chloride or sulphur dioxide as a refrigerant. It is considered tentative and is open to correction or addition. The committee is now awaiting the results of the work done by the subcommittees on welding and on the specification of a standard ton of refrigeration. There will be additions to the code on these two items, and further suggestions are solicited by the committee. About twenty cities have now adopted the code as it stands. In the discussion reference was made to the preparation of a separate code for an electric-driven plant; this to avoid complication and preserve the simplicity desired. The present code will appear in full in an early issue of *Power*.

President G. E. Wells made a general address, reviewing briefly some of the recent work of the society and requesting more activity in securing new members. Owing to the many new applications of refrigeration, he said, opportunities for the refrigerating engineer are greater than ever before. More attention should be paid to the appearance of plants, particularly in the Southwest. Because of the higher cost of fuel and supplies, improved efficiency is a prime importance and labor must be given more consideration than in the past.

Mr. Hiller's Paper

A paper by N. H. Hiller, describing a "Shop Method for Testing Refrigerating Machines" was received with interest. In the past 15 years the company with which the speaker is connected has installed four test plants at an average cost of $5000. As they required the services of five men, the cost of operation was high. Many difficulties were encountered and long delays made it difficult to interpret changes in the refrigerating apparatus. Consequently, a new method employing a high-pressure orifice was tried. The compressor discharged into a high-pressure receiver and then through a valve into a low-pressure receiver equipped with a special form of nozzle recommended by the Compressed Air Society, and a manometer. By means of the regulating valve between the receivers the pressure was kept constant in the high-pressure tank. The equipment gave excellent results with compressed air, but was rather complicated. In an effort to simplify the plant an adaptation of this nozzle method was used. The problem was to obtain constant conditions of pressure and a means of measuring the volume of the gas pumped and thereby its weight. Receivers were employed as before, temperatures measured on both sides of the nozzle, and an oil manometer was used. A sprinkling trough was provided to reduce the superheat in the high-pressure receiver to a temperature slightly above that due to the pressure, and grids and baffles were installed to break up the gas current and prevent vortex action. This apparatus gives all the conditions of a complete refrigerating plant except that of a saturated gas suction, and to meet this a small double-pipe condenser and a calibrated receiver with gage-glass are provided, the latter being connected into the suction line through a valve which can be regulated to maintain any desired temperature of the suction gas. Ascertaining the quantity of liquid flowing through the regulating valve by means of the gage-glass and adding to this the quantity indicated by means of the nozzle gives the total volumetric capacity of the compressor.

To give comparative data in the shop the foregoing is all that is needed. The various parts of the system, however, may be cut into the suction line of any installation and left permanently connected. Results within 2 per cent. of the actual capacity might be expected. The apparatus can be attached also to the suction line of an absorption plant. Its value in detecting any falling off in capacity and in obtaining comparative data before and after changes, would be great.

Monday Afternoon Session

At the afternoon session, Monday, E. F. Mueller, of the National Bureau of Standards, presented an interesting paper on the "Physical Properties of Brine." The relation between specific gravity and other properties of brine was discussed and the need of proper tables giving the properties of both calcium-chloride and sodium-chloride brines was emphasized. As soon as accurate data are available on the thermal expansion of brines below 32 deg. F., it is the intention of the bureau to issue these tables as a bureau circular. The form of the tables and method of arrangement were indicated in the paper. An interesting digression was an explanation of the phenomena occurring on cooling a brine below its freezing point.

In a paper on "Improved Cold-Storage Methods," F. E. Matthews referred to the work being done by the Bureau of Markets, United States Department of Agriculture, to effect better world provisioning. Better distribution of foodstuffs by cold storage is a problem of vital importance. The present prodigality is illustrated by the fact that over 15 per cent. of the food is wasted before reaching storage and 19 per cent. after it is placed on the market from storage. More and better food to the consumer could be had by increasing production and lessening storage rates due to the greater volume. One of the present difficulties is the lack of uniform rates on cold-storage products, due to the varying shapes of the commodities and the waste space in piling, ranging on the average from 25 to 50 per cent. The load factor of the warehouse as well as the load factor of the refrigerating plant has a big effect on the net earnings.

The Bureau of Markets has developed a standard cost-accounting system for cold-storage warehouses. Uniformity in the various plants is important so that intelligent comparisons of results can be made for the purpose of eliminating bad practices and establishing equitable rates. Those commodities taking too much space and those paying their way can be detected and adjustments made.

The discussion centered on the prejudice against cold storage and its gradual elimination, preparation of the product before freezing, the need of a better system of getting the product from the retailer to the consumer, and the desirability of being more strict in accepting products for storage.

"Refrigeration in the Chemical Industry" was a topic on which there was some discussion. Reference was made to indirect application as in the crystallization of chemical products and direct application in the manufacture of chemicals for the preparation of dyestuffs. Cooling of chemicals by heavily icing the coils or by brine circulation through star-shaped elements was referred to specifically by Fred Ophuls, of New York City.

Tuesday Morning Session

On Tuesday morning the initial subject was "Refrigeration at Edgewood Arsenal," by J. O. Schultz. During the war the arsenal became the world's greatest toxic-gas plant. A great variety of gases in enormous quantities were made. Refrigeration was needed to cool the shells to be filled, to cool the liquid entering the shells and to de-

hydrate the air used to force the liquid into the shells. Mustard oil, for example, required two tons of refrigeration for each ton of gas making. A temperature of 15 deg. was maintained in the oil-cooling and shell-cooling rooms. At the time of the armistice a total of 1357 tons of refrigeration had been installed.

A discussion on cooling towers was opened by J. B. Harry. Brief summaries were given of spray cooling systems and of natural ventilation and fan-draft towers and the combination tower. The highest efficiency with the least loss of water could be obtained with an atmospheric tower of proper design. For the construction of the tower, including the louvers, steel is the best material if frequently inspected and kept properly painted. Acid in the air collecting in the water and becoming concentrated in time necessitates changing the water at intervals or the introduction of alkali to neutralize the acid. The speaker told how wind shields were formed and attached to the structure in the particular tower in which he was interested. The saving in water by the use of a properly designed tower might reach 98.5 per cent. There was further discussion on the use of tile and concrete to avoid iron and the attending corrosion and the use of wood to eliminate repairs. Reference was made to the desirability of standard specifications of performance and of standard towers. With open towers the average wind velocity is a vital factor. Other points to be considered are the wetted surface, the collecting and breaking up of the water at intervals and the retardation of the drops to keep the water in the air as long as possible. Spray systems require nearly as much power as the fan tower and in addition there is considerable loss from windage.

Advantages of the high-speed ammonia compressor are less space occupied, more adaptable for direct connection to motors and higher efficiency. The cost is as much or more than that of a slow-speed machine of the same capacity owing to high-grade construction. The success of this type hinges on the discharge-valve area. With poppet valves the speed was limited if efficiency and noiseless operation were to be maintained. The feather valve had advantages and was now being introduced into the refrigerating field. Keeping the compressor properly keyed up was of great importance as the momentum increased as the square of the velocity.

Mr. Ormsby's Paper

"Men and Machinery in the Ice Manufacturing Plant" was the subject of a paper by Ermle S. Ormsby. The speaker expressed his belief in thoroughly good plants and in refinements tending toward economy, but maintained that the man operating the plant plays a more important part in obtaining efficiency than the machinery. Back of the man the support and confidence of the management are essential. Initiative should be encouraged, and the system of order and drive must give way to leadership and proper consideration. Poor choice of men and low salaries invariably result in low economy. A number of plants were reviewed, and those complying with the suggestions cited previously were paying dividends. In the discussion Colonel Rushton emphasized the importance of coöperation between department heads. The men should be encouraged and given every opportunity for advancement. Understudies all the way along the line are desirable, and unless absolutely necessary, outsiders should not be brought into the organization.

In a paper by John E. Starr, the point was made that although engineering is an exact science, the success of the engineer depends on his ability to reduce his conclusions to terms of cash. Obsolescence and interest on initial investment may overbalance the cost of operation. Whether to buy expensive, economical machinery or cheap machines of lower economy depends on conditions, length of service, etc. It is not so much the choice of efficient machinery as the selection of equipment that will give the best returns on the money invested.

A discussion on the relative advantages of ammonia compression versus absorption refrigerating machines for cooling water did not bring out anything new. As no specific set of conditions was assumed, the conclusions were those generally accepted. A subsequent explanation by Fred Ophuls of a new ice-making system he was perfecting proved interesting. The system is based on the fact that water can be cooled below 32 deg. F. without freezing and then at the slightest jar will flash into ice crystals. The main difficulty has been to find out why the water flashes into ice at 31.5 deg. at one time and at 29.5 deg. at another. It was discovered that the refrigerating medium has to be at a certain temperature and that the shape of the can has a bearing. The formation of loose crystals is avoided when the water is only slightly supercooled. Mr. Ophuls sketched the can, showing supercooled water coming in at one end and a continuous cake of frozen ice coming out at the other. Oil lubricated the surfaces so that the cake of ice passed along freely. It is necessary to circulate four pounds of water for each B.t.u. abstracted, but the quickness of freezing insures a large output in comparatively small space.

Reports from the various chapters brought out the suggestion that discussion of papers already presented and printed by the society would be more advantageous to the sections than the presentation of papers bordering on the commercial or of papers by the rank and file on which little time had been spent with the idea in view that they would not be printed.

The usual banquet was held Tuesday evening, and the following day was given over to the inspection of industrial plants and an automobile ride about Cincinnati.

Water-Power Bills Introduced in Congress

Water-power legislation in three different forms has been introduced in the Senate at the present extraordinary session of Congress, and the House of Representatives has passed a rule providing for the creation of another special water-power committee similar to that which worked a bill through the House at the last session of Congress, although the proposed legislation failed in the Senate as the old Congress ended, owing to the filibuster on President Wilson's foreign policies.

Representative Campbell, of Kansas, took a leading part in having the House pass the rule providing for the new committee. The rule is as follows:

> Resolved, that the Speaker of the House be, and he is hereby authorized and directed to appoint a special committee of eighteen, to whom all bills and resolutions heretofore or hereafter, introduced during the Sixty-sixth Congress pertaining to the development or utilization of water power shall be referred, notwithstanding any general rule of the House to the contrary.

The three forms in which legislation has been proposed in the Senate are as follows: A bill (Senate 152) by Senator Jones of Washington, to create a Federal Power Commission and to define its duties and powers, to provide for the improvement of navigation, for the development of water power, and for the use of the lands of the United States in relation thereto, which was referred to the Committee on Commerce; a bill (Senate 220) by Senator Walsh of Montana, to amend the act to regulate the construction of dams across navigable waters approved June 21, 1906, also the act approved June 23, 1910, and to provide for the improvement and development of waterways for the uses of interstate and foreign commerce, which was referred to the Committee on Interstate Commerce; a bill (Senate 651), by Senator Shields of Tennessee, to provide for the construction of dams across the navigable waterways of the United States, for their improvement and development, and to provide for the lease and use of public lands and the development or utilization of water power in the streams running through or adjacent to them.

The bill introduced by Senator Walsh is practically identical with the report made by the Conference Committee at the last session of Congress. It provides among other things for the issuance of permits for the development of water power for a period not exceeding fifty years.

Preliminary permits not exceeding three years may be issued for the sole purpose of maintaining priority of application during the time necessary for making examinations and surveys.

Whenever in the judgment of the commission the development of any project should be undertaken by the United States itself, the commission shall not approve any applications received from other parties.

No transfer of license or of the rights thereunder granted are allowed without the approval of the commission.

After the first twenty years of operation the licensee shall establish and maintain amortization and reserve.

The licensee shall pay to the United States reasonable annual charges in an amount to be fixed by the commission. This does not apply to such power as is used for state or municipal purposes, or to power for domestic mining or other beneficial use in projects of not more than fifty horsepower.

Combinations, agreements or understandings to limit the output of electrical energy, to restrain trade or to fix, maintain or increase prices for electrical energy are prohibited.

The licensee is required to begin the construction of the work within the time fixed, unless an extension be granted by the commission, and shall prosecute such construction in good faith, and shall from time to time thereafter construct such balance of the development as the commission shall deem necessary to meet the demands of the market. Noncompliance with this shall make the license revokable.

Upon not less than two years' notice the United States would have the right, upon or after the expiration of any license, to take over and operate the property, in which case it would be required to pay the net investment not to exceed the fair value of the property plus reasonable damages, if any. The net investment is taken as the actual original cost plus additions and betterments minus unappropriated surplus, depreciation, sinking fund or similar reserves.

If the United States does not at the expiration of the license exercise its right to take over the property, the commission is authorized to issue a new license to the original licensee upon terms consistent with the then existing laws.

Rates are left to the regulation of the state utilities commissions.

The bill introduced by Senator Jones is in many respects similar to the Walsh bill. It provides in addition that the Government will make investigations and collect data concerning the power industry, its relation to other industries, markets for power, and ascertain whether the power from government dams may be advantageously used by the United States for public purposes; such information to be made public from time to time. The licensee would be required to pay such annual charges as may be fixed by the commission solely with a view to reimbursing the United States for the actual cost of administration; such charges to be readjusted if necessary not oftener than once in two years. Further, that grants for the development or transmission of power for domestic mining or other beneficial use in projects of not more than five hundred horsepower capacity may be issued without charge. In the Walsh bill this is fifty horsepower.

Both bills provide for the taking over of the property by the Government where in the opinion of the President the safety of the United States demands such action.

The Shields bill would place the granting of permits in the hands of the Secretary of War when pertaining to navigable streams, and the Secretary of the Interior when pertaining to public lands. It has the fifty-year recapture clause the same as the other two bills, but the value of such property shall be determined by agreement between the Secretary of War and the grantee provided that no values shall be claimed for the rights granted, for good will or anticipated profits.

Representative Gillette, the Speaker of the House, announced the personnel of the new water power committee as follows:

Representatives Esch, of Wisconsin; Hamilton, of Michigan; Winslow, of Massachusetts; Sinnott, of Oregon; Smith, of Idaho; Elston, of California; Haugen, of Iowa; McLaughlin, of Michigan; Anderson, of Minnesota; Sims, of Tennessee; Doremus, of Michigan; Barclay, of Kentucky; Ferris, of Oklahoma; Taylor, of Colorado; Raker, of California; Lever, of South Carolina; Lee, of Georgia; and Candler, of Mississippi.

Investigation of Wire Rope*

By J. H. Griffith†

The Bureau of Standards for a number of years has conducted investigations having for their purpose the collection of facts concerning the strength and other properties of wire rope. The following is an abstract of some of the important data pertaining to the relative strengths of steel hoisting ropes when they are used on sheaves of different diameters, as in the case of the block and tackles for cranes and derricks.

It is shown in the dynamics of materials that a sudden application of a load, as in the case of the lifting of a weight by a crane, may cause strains that are double those experienced when it is applied gradually. On the other hand, a sudden reversal of stress may cause maximum strains three times those obtained when the reversal is made slowly. Kinetic effects may therefore be assumed to have static equivalents which in any case should not exceed the strength of the block and tackle, which will be limited, in turn, by the strength of its component parts, namely, the socket connecting cable to hook the sheaves, axles and pins. It is known, moreover, that the "quick" modulus of elasticity for metals differs only slightly from the "slow" modulus. It was assumed in conducting tests that the behavior of a number of "fall lines" and sheaves in parallel may be approximated for practical purposes by the testing of a single loop of cable over two sheaves. The tests were conducted upon plow-steel cables of six strands of 19 wires each, varying in diameter from ⅝ to 1¼-in., the sheaves being 10, 14, and 18 in. in diameter, the sizes most commonly used in practice. The following results were obtained:

Variation of Relative Strengths of Cables

Let it be supposed, first, that the strength of a cable when tested in direct tension represents a datum of 100 per cent. The mean relative strengths of cables of diameters ⅝ in. to 1¼ in., as found by actual tests, may be approximately represented by linear laws as follows: The strength on 18-in. sheaves when tested in the manner previously described varies from 96 per cent. for ⅝-in. cables to 87 per cent. for 1¼-in. cables. The corresponding values for 14-in. sheaves vary from 95 to 82 per cent. and for 10-in. sheaves from 84 to 77 per cent. The mean departures from the linear law were about 1 per cent. (±) and the maximum about 2 per cent. (±) for the different cases, except in the case of the ⅝-in. cables on 10-in. sheaves, where it was 4 per cent. higher than the law calls for. In other words, the relative strength in this case was actually 88 per cent.

On the other hand, let the datum of 100 per cent. represent the mean aggregate strengths of the component wires as found from individual tension tests. The strength of cables in direct tension by the approximate linear law varied from 85 to 88 per cent. in a range of diameters ⅝ in. to 1¼ in. inclusive. The corresponding strengths on the 18-, 14-, and 10-in. sheaves vary approximately from 82 to 75 per cent., 80 to 72 per cent., and 71 to 67 per cent., the mean departures in absolute values (±) being about 1½ per cent. and the maximum 3 per cent.

Cable Fracture Occurs at Tangent Point

The cables usually fractured at the point of tangency with sheaves. The sockets, pins and axles developed the strengths of the cables in each case. On the other hand, cracks developed in several of the sheaves either at hubs

*Abstract of a report by the Bureau of Standards, Pittsburgh Pennsylvania.

†Associate engineer physicist, Bureau of Standards.

or rims, indicating that there were opportunities for improvements in design in this respect.

The following table shows the average tensile strengths of the straight specimens, this being one of the datums used in the preceding comparison, together with the strengths on sheaves:

STRENGTH OF PLOW-STEEL HOISTING CABLES OF SIX STRANDS OF 19 WIRES EACH

Diam. of Cable (Inches)	Average Strength, Tested in Direct Tension: In Pounds	In Pounds per Sq.In.	Modulus Pounds per Sq.In.	Tensile Strength of Cable on Sheaves: Diam. of Sheaves Inches	Average Breaking Load: In Pounds	In Pounds per Sq.In.
½	32,000	205,000	7,600,000	18	30,700	197,000
				14	30,900	198,000
				10	28,170	180,500
⅝	50,000	221,000	8,900,000	18	45,840	202,500
				14	45,360	200,000
				10	39,840	176,000
¾	63,000	194,000	7,600,000	18	58,400	179,500
				14	56,300	173,500
				10	51,480	158,200
1	82,000	197,500	8,900,000	18	75,540	182,000
				14	71,680	172,500
				10	65,000	156,500
1¼	132,000	209,000	6,300,000	18	110,180	176,000
				14	106,330	168,200
				10	99,080	157,000

The load in direct tension in terms of the diameter for plow-steel hoisting cables of six strands of 19 wires may be approximated by the formula $L = 83{,}000\ d^2$.

In the case of the ¾-in. cables, some tests were conducted on two samples that had been in use about five years. It was found that the strengths of the individual wires was much decreased by wear, corrosion or indentations. Many were found to be broken in service. Repeated load tests showed a considerable reduction in the resiliency, with a corresponding increase in the modulus. One specimen, in spite of its defects, bore a load of 50,000 lb., practically that of the average new specimens, whereas another failed at a load of 36,000 pounds.

Results of Wire-Rope Tests

The following is a brief summary of some of the results found for the wires: (1) The elongations varied from a minimum of 1.25 per cent. to a maximum of 3 per cent., with a mean of about 2 per cent. (2) The permanent elongation and reduction were largely local, occurring mostly at the point of fracture. (3) The elastic limit of the twisted wires was about 65 per cent. (4) The average tensile strength of the wires was approximately 225,000 lb. per sq. in. (5) It was found in these tests, as in others that have been conducted on used cables, that the item of lubrication is important in lengthening the life of a cable and preventing internal corrosion. The latter increases friction of the wires and prevents a proper distribution of load through the strand. It, moreover, impairs the strength through reducing the cross-sectional area.

Planning for Power*

By GEORGE OTIS SMITH
Director, United States Geological Survey

THERE has been, fortunately, some progress in our ideas of what is the true relation between government and business. Governmental coöperation with business is the next step. Industry itself is indeed coöperative and social by nature, and the bigger "big business" becomes the greater its need of socialization in the true sense.

These are days of "changing gears" on the big industrial machine of our country. Under the war-speed conditions we took everything on "high," regardless of either economy or safety. Now we have slowed down to "look and listen," and Business must decide which speeds are best suited for the long pull ahead. The time is therefore opportune for broad planning, and there is no more urgent need than that of a power program.

As I see it, power is the great industrial need of the day—without it the speeding up of our nation in its recent great effort to help save the world would have been impossible. Try to think of our war-time program in terms of unaided human energy; even as it was our great transportation systems almost broke under the task. The transportation of raw materials and manufactured products even in peace times calls for herculean energy—a power demand measured by more than five million continuous horsepower. Compare, if you will, the energy of the coolie crossing the mountains of central China with his backload of tea and the energy of the electric locomotive hauling copper ore from mine to smelter or ammunition from Bridgeport to New York, and you realize what electric power means in transportation.

In terms of cost, the best figures available indicate that motive power accounts for fully 30 per cent. of the expense of operating steam railroads and for about 10 per cent. of the well-managed electric railways. Aside from this difference in power cost, electric energy must be credited with the greater efficiency it makes possible.

The power element is smaller in manufacturing than in transportation, but not less important. In the making of cotton cloth about 2 per cent. of the value of the product can be charged to power, while in the production of electrolytic zinc the power cost is around 12 per cent. In general, 2 per cent. may be taken as a conservative figure for the power item in total manufacturing cost, and this may seem almost negligible, but the wider use of power in mills and shops has a larger effect than is measured by its own cost—the kilowatt-hour may double the product of the man-hour, and men cost more than kilowatts.

Electric power, as furnished from the large central stations, is favored by that happy economic law whereby the load factor works both ways. Lowering the cost of electric energy invites greater use, and greater and more diversified use permits lowered cost. That is no vicious circle; it is the virtuous upward curve of progress.

The story of wastes in our national career is not a pleasant one. Your best engineers see the trouble—the growth has been so rapid that we have given too little thought to systematic development. Wonderfully well thought-out units are scattered here and there, but these are widely separated islands in a sea of poorly planned or obsolescent plants.

You gentlemen know far better than I the wide span between your best records in large up-to-date central stations and the results obtained in smaller and often obsolescent private plants. Measured by coal burned to the kilowatt-hour the ratio is 1 to 2 or 3, or even more. Where else do we find such opportunities to cut down the coal bill? We can see even greater savings when we consider the advantages of hitching up American rivers and American coal—they work best in double harness. I believe that we are far from making full use of the water powers that lie undeveloped within easy transmission distances of our largest power markets. It is, moreover, time to count the rising costs of labor in the steam plant, where the coal miner as well as the fireman is an employee in fact, whether you see the miner's name on your payroll or not. The figures presented by the Alabama Power Co. in its comparison of steam plant with hydro-plant show the ratio of men employed as 84 to 1. Conservation of human energy calls for the immediate and full development of every water-power that is feasible.

In comparing the efficiency of the steam locomotive with that of the electric motor, I think of the switching engine as a self-contained power unit having the worst possible

*Abstract from a Lecture given before the National Electric Light Association at its 42nd Annual Convention, held in Atlantic City, May 19 to 22, 1919.

load factor. Here we find one ton of coal converted at the central station into the electric energy delivered to the electric motor doing the work of four tons shoveled under the boiler of the locomotive. Even with the better load factor of the passenger locomotive, there is little room for difference of opinion when we learn that the Merchants' Limited requires only half as much coal per mile between New York and New Haven as between New Haven and Boston. Can we afford to burn two tons of coal where one will pull the load?

The Secretary of the Interior offers a power program, and his program is inspired by a vision of future needs. He regards the almost insatiable demand for power created by war industries as foreshadowing future danger of power famine in the industrial districts of the Northeast. The signing of the armistice happily averted the power crisis that otherwise we would now be facing. Now, however, a policy of preparedness for peace expansion should be adopted.

This administrative officer's recognition of the urgency is, then, in full harmony with that definition of vision quoted by a leading engineering corporation: "Experience is the only prophecy of wise men." Secretary Lane looks upon the present relief from power famine as only temporary. In his statement to Congress he said: "In a few months, and especially in the regions mentioned, I anticipate a greatly increased demand for energy, for which present facilities are inadequate. This demand will follow the resumption of industry under the operation of normal economic laws and in the face of international competition, factors that have been largely inoperative during the war. If the country is to reap the full benefit of this returning wave of activity, it must be prepared to furnish industry and transportation with an adequate, dependable and economical power supply. Only by increased economy in the production and distribution of power will it be possible for our manufacturers to decrease their production expenses and compete successfully in the world's markets, maintaining at the same time the American standard of wages and living."

Power Conditions in the Whole Country

The Secretary of the Interior has asked of Congress two appropriations—one of $50,000 for continuing this power survey, undertaken by the Geological Survey, covering the whole United States, which was begun in coöperation with the Fuel Administration and at its request, and the other of $200,000 for an intensive survey of the region where power requirements are most congested. Secretary Lane proposes to study conditions in the whole country, so that we may all see the picture of present conditions and the possibilities of future growth and may be able to plan to meet that growth with the greatest economy to the nation in fuels, labor and materials. For the first fields of work, he has selected that area of maximum power density which he has chosen to call the North Atlantic Industrial District, an area that has somewhat indefinite geographic boundaries, but that is clearly defined industrially and economically. In this area, extending from the vicinity of Boston to that of Washington or Richmond, and covering 50,000 square miles, is concentrated one-fourth of the power-generating capacity of the whole country.

The need of knowing the facts is realized when we try to measure even present power requirements, not to mention future demands. The Boston-Washington region uses 600,000,000 kw.-hr. a month, most of it derived from coal. The central stations alone consume fully 10,000,000 tons of coal a year; add to this, say, 25,000,000 tons for the railroads in this area, and we begin to appreciate in a general way the part coal plays as a source of motive energy.

In conducting these inquiries the Geological Survey must of course rely upon the coöperation of the electrical industry and, as was expected, this coöperation has been almost universally given, the Survey's analysis of February operations representing over 92 per cent. of the output of the country. You will realize that a monthly report of the country's power output makes the most sensitive of business barometers, for unlike coal and steel records it is unaffected either by any carried-over surplus or by orders for future use.

I trust, too, that this coöperation is not one-sided, for the Government bureau is in a position to assist your industry in many ways. I may mention one way: The manufacturer seeking a location for a new plant comes to the Geological Survey with his statement of requirements in raw materials, transportation, power and labor. From the knowledge obtained from you gentlemen, this Government bureau is able to suggest localities where he will be likely to get power at reasonable rates and to refer him to several power companies that can meet his requirements. The average manufacturer seeking power is today very much in the dark, and any clearing house where the industrial man can be introduced to the power man and where the only wish is to do both a service must be of real value to the industry.

Picture of the Super-Power System

My own picture of the super-power system that would effect the economies demanded by the rapid growth of this industrial region includes a multiple transmission line of high voltage with its thousands of steel towers extending from Boston through our Eastern States, crossing the Connecticut near Springfield, the Hudson at Poughkeepsie, the Delaware near Easton, and the Susquehanna below York, and so on to Washington and Richmond. Into this unified system large-unit steam-electric stations at tide-water and near the mine mouths and hydro-electric stations—20 or more—at old and new sites would deliver energy as required, and from this great power main would flow the energy to serve a score of railroads, hundreds of public-service companies, thousands of manufacturing plants and millions of homes.

As one of my engineer friends remarks, this project would appear a "large order," and at first it staggers the imagination, but such a super-power line extending from Boston to Washington cannot be termed only a dream. Secretary Lane has pointed out that in his own State of California there are systems of electric transmission comparable with this in length if not in capacity. If you take your map of the United States and make the West move East—which I admit is contrary to human experience—you can take one end of an existing trunk power line, which is at Tonopah, Nev., and lay that on Boston, and then the other end of the line, which is actually at Yuma, Ariz., and can be placed at Norfolk, Va. What we dream for the East exists in the West, where the extreme tentacles of one system of interconnected power plants now have a reach of nearly 500 miles.

As a nation bounded by the two oceans we own 55 per cent. of the world's coal, yet the tonnage remaining in the great producing fields of the East is so limited as to make coal saving a topic deserving the best thought of those concerned in power generation. And coal from the more distant fields will be more expensive coal.

Cheap Power an Asset of First Rank

Meeting the need for cheap power, however, has far more than a local significance. Cheap power is already an asset of the first rank to any country in the international contest for world markets. With the strategy of war fresh in mind, we may look upon this Atlantic Seaboard Industrial Region as the American front trench in the commercial rivalry among nations. This is the reason that Secretary Lane, while asking Congress for a general survey of the power resources of the whole country, wishes also to make this more intensive study where the need is greatest and most urgent.

America's comrades in arms, France and Great Britain, are wide awake to their peace needs. They recognize cheap power as a key to the markets of the world, although the reference in British reports to the electrical industry as a "key industry" doubtless means that electric power is the keystone in the national industrial arch. Already in England, five official commissions have submitted reports on the question of power development, in which they empha-

size the national importance of cheap power as a vital requirement. They consider electric power as essential as labor and material in economic production. They reiterate that in England less power is used by certain industries than is used by similar industries in the United States, where the larger net output per operative employed and the higher rates of wages show the advantage both to capital and to labor.

In working out their national program these British commissions condemn the existing provincial and parochial systems of generating and distributing electricity and urge a centralized and unified power system as the only method of conserving their coal supply by getting the fullest value from every ton consumed and thus furnishing cheaper power to the industries, large and small.

Our interest as citizens in these plans for cheaper energy is far more than a commercial interest. Public service is a term that has come to attach itself to your industry, and not without reason. The organization of the nation's business to obtain the lowest costs is distinctly a matter of public service, in which corporation and Government bureau may well join efforts, but success in this organization of industry is not to be measured in dividends alone. Tomorrow prosperity must mean profit sharing on a thoroughgoing scale, in which we shall all receive in proportion as we have served. So the industrial program which emphasizes mechanical power is the most effective assurance of better conditions for all who work in this busy world of ours. To improve living conditions for all our citizens must be the aim of those to whom is given the privilege of leadership in industry. Secretary Lane has said that "upon our shoulders rests the burden of proving that free government can live. America is the ultimate citadel of human liberty."

Fusing Potential Transformers

According to the report of the Meter Committee of the National Electric Light Association, presented at the 42nd annual convention, question has arisen at different times in committee meetings as to the practice of fusing potential transformers used with watt-hour meters.

The fuses used on potential transformers to serve the purpose as a fuse are liable to be light and fragile. The loss of a fuse either mechanically or electrically means the loss of the element on one phase. With a load of inductive characteristics, that particular phase might be carrying a relatively small percentage of the total load. For this reason the blown fuse might go undetected for a considerable period with a consequent significant loss of revenue.

Question arises, therefore, as to the desirability of eliminating the fuses on the potential transformers. A survey by the committee itself indicated that 80 per cent. of the companies represented use potential transformers unfused on meters on circuits of 6600 volts or less.

The suggested use of a limiting resistance in the primary in place of the fuses is a questionable practice from the standpoint of introducing possible errors.

Authority to impose a 10 per cent. surcharge on its electric rates beginning May 1, has been granted the Northern California Power Co., consolidated, operating in Shasta, Tehama, Glenn, Butte, Colusa, Yolo and Trinity counties, by the state railroad commission. The company had asked for increases ranging from 14 to 35 per cent. The surcharge will not apply to those portions of Butte and Colusa Counties where the company is in competition with the Pacific Gas and Electric Co.

Personals

Paul T. Buckler has been released from service in the Navy and is back at his old job in the New York City office of the Detroit Stoker Co.

Frank J. Tone has been elected president of the Carborundum Co., Niagara Falls., N. Y., to succeed the late Frank W. Haskell. George R. Rayner has been made vice president to succeed R. B. Mellon, of Pittsburgh. F. H. Manley retains the office of treasurer.

M. H. Jones, who has been connected with the Westinghouse Electric and Manufacturing Co. for the last fifteen years as assistant to the manager of the Philadelphia district, has resigned to become sales manager of the Standard Electric and Elevator Co., of Baltimore.

Joseph W. Greves, who was connected with the Otis Elevator Co. for a number of years, and during the war was an instructor in the machine department of the Submarine Boat Corp., at Port Newark, N. J., has accepted the position of superintendent and chief engineer of the new Elks Building, Jersey City, N. J.

John E. Muhlfeld has resigned as president of the Pulverized Fuel Equipment Corp. and has associated with him several other engineers and formed the Railway and Industrial Engineers, Inc., with offices at 25 Broad St., New York City, to act as consulting and advisory engineers to bankers, railroads and industrial corporations. Mr. Muhlfeld has, for the last five years, been specializing in the development of the "Lopulco" system for burning pulverized fuel in locomotives, stationary boilers and metallurgical and chemical furnaces. He will retain his interests in and remain a director of the Pulverized Fuel Equipment Corporation.

Colonel Douglas I. McKay has been elected president of the Pulverized Fuel Equipment Corp., of New York City, to succeed John E. Muhlfeld, who retired to return to consulting engineering practice. Colonel McKay has been engaged in war work since July, 191 At that time he was commissioned major in the Ordnance Reserve Corps in charge of the Raw Materials Branch of the Gun Division. In January, 1918, he was promoted to lieutenant colonel of the National Army and appointed assistant director of Purchase and Supply. He was subsequently promoted to colonel and continued in this capacity until he returned to civil life after the armistice was signed. He was formerly first deputy police commissioner and later was police commissioner of New York City. After he resigned the commissionership he became assistant to the president of J. G. White & Co., Inc., and two years later was elected vice president and director, which position he held at the time he entered the Army service. In addition to being president of the Pulverized Fuel Equipment Corp., he is vice president and director of the Chemical Foundation, Inc., director of the International Agricultural Corp. and director of the Botany Worsted Mills.

Engineering Affairs

Indiana State Association, N. A. S. E. annual convention will be held at Terre Haute, June 26-28.

The National Electric Light Association, Iowa Section, will hold its next convention at Colfax, Iowa, June 18-20.

The Society of Automotive Engineers will hold its spring meeting at Ottawa Beach, Mich., June 23-27.

The American Association of Engineers, New York Chapter, has elected the following officers: President, Alexander Potter; first vice president, J. C. Patterson; second vice president, Maurice Griest; treasurer, Hugh C. Jackson; secretary, E. B. Miller.

Taunton Association No. 25, N. A. S. E., of Massachusetts, held its twenty-third anniversary on Saturday, May 24. The attendance was unexpectedly large, among those present being many prominent association members. There were interesting talks and a good entertainment. Refreshments were served.

Springfield Council No. 23, Universal Craftsmen, Council of Engineers, was instituted at Springfield, Mass., on May 1, at the Engineers' Hall. There were upwards of sixty charter members. Walter H. Damon, chairman of the organizing committee, was elected worthy chief.

The National District Heating Association will hold a Victory convention at the William Penn Hotel, Pittsburgh, Penn., June 10-13. At the same time and in the same hotel the American Society of Heating and Ventilating Engineers will hold its summer convention. Wednesday's (June 11) session will be a joint meeting of the two associations. A fine program has been laid out for all the meetings, and it is anticipated that this will be the largest and best convention the association has ever held.

Miscellaneous News

The Bureau of Mines, Department of the Interior, will formally dedicate its new million-dollar laboratories and workshops in Pittsburgh, Penn., with fitting ceremonies Sept. 29-Oct. 1. High Government officials, together with the governors of the principal mining states, and leaders in the mining industries and mining organizations will take part in the dedicatory ceremonies. A spectacular feature of the dedication will be a great, national safety-first meet, with teams of miners from all over the country competing for prizes. Visitors will be invited to the electrical and mechanical workshops and laboratories of the Bureau and also to the petroleum, gas and coal laboratories, the testing gallery of the mine safety section, and the industrial gas-mask division. An exhibit representing the mining and metallurgical industries of the country. Visits will be made to typical Pittsburgh industries.

An Anniversary Dinner for John A. Stevens, of Lowell, Mass., in recognition of the completion of the first ten years of successful business, was given to him by his associate engineers and assistants at the Hotel Thorndike in Boston, Mass., Saturday evening, May 17. About forty members of the organization were present, and an informal reception was given to Mr. and Mrs. Stevens before the dinner. The menus, or "Fundamental Data," as they were called, were written in engineering terms and included such novelties as "extra heavy hi-valves," "assorted bolts and nuts" and "turbine oil." These menu programs were very attractively and appropriately designed, the front cover illustrating one of the first plants built in 1909 and a very large proposed super power house, the design of which was recently made in Mr. Stevens' office. There were some after-dinner speeches and at the conclusion Mr. Stevens was presented with a loving cup on behalf of the members of the organization.

Business Items

The Wellman-Seaver-Morgan Co. announces the opening of an Atlanta office at 318 Hurt Building, in charge of E. R. Kenner.

The Leeds & Northrup Co., Philadelphia, Penn., has opened a pyrometer sales and service department at 1304 Monadnock Block, Chicago, with Henry Brewer in charge.

The Hill Pump Valve Co., of Chicago, Ill., has purchased a tract with frontage on Belmont and Knox Avenues, upon which it will erect a new $500,000 plant intended to be as modern and well equipped factory as there is in the country.

The Dominion Asbestos and Rubber Corp., of New York City, has recently opened branch offices in Albany, N. Y., Atlanta, Ga., and Allentown, Penn. The capital stock of the company was recently increased, and with the cessation of hostilities the company is now able to devote its energies to the sale of its products in the industrial field.

Trade Catalogs

The Buffalo Forge Co., Buffalo, N. Y., has issued its catalog Section No. 400, on "Fans, Blowers and Exhausters," fully describing and illustrating the design and structural details of these company products.

The Superheater and Engineering Co., New York City, has issued an 11-page bulletin on "Dravo Superheaters." An instructive bulletin showing various applications of the Dravo superheater with introductory page on the "Conservation of Fuel."

"Davison Burners" is the title of a 20-page catalog just issued by the N. C. Davison Gas Burner and Welding Co., of Pittsburgh, Penn. As well as a full description of the various burners, the booklet contains some useful information on steam boilers, tables showing gravity of fuel oils, specific heats, and rule for figuring B.t.u.'s in fuel oil.

The Locomotive Superheater Co., of New York City, has just issued an 8-page Bulletin T-2 entitled "Superheaters for Stationary Power Plants." The bulletin illustrates and tells how the Elesco superheater is the theoretically correct and practical method of securing the advantages of the use of superheated steam in stationary boilers. A copy may be had free upon request.

"Murray Steam Power Plants" is the title of a 95-page catalog No. 85, just issued by the Murray Iron Works Co., Burlington, Iowa. This catalog contains 85 illustrations with information on different types of boilers and Corliss engines, marine engines, pumping engines, governors, valve gears and other boiler and engine accessories; also table of horsepowers.

The Metal and Thermit Corp., New York City, has issued a folder entitled "How Thermit Healed My Broken Jaw," which illustrates the operations involved in making a Thermit weld on the 13½-ton broken upper jaw of an alligator shear used by the Jos. Joseph & Bros. Co., Modena, Penn. The break welded was 80 in. in length and varied from 4½ to 23 in. in thickness.

The Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has just issued a 62-page booklet No. 137 entitled "Works and Products," presenting in condensed form a description of the company and its capacity for producing a great variety of machinery, including the largest and most powerful prime movers and electrical machinery in the world; also detailed information with reference to the company's plants and products.

The Tide Water Oil Co., New York City, has recently published an interesting 46-page booklet on "Fuel Oil." In addition to the material on the various kinds and uses of fuel and crude oils, details are given regarding the use of fuel oil in metallurgical furnaces for either ferrous or non-ferrous metals, ceramic work in its various branches, gas manufacture or enrichment of water gas, steam for power, Diesel or other internal-combustion engines. The booklet is intended to be of service not only to the nontechnical executives and plant managers, but also to the plant engineer. It is well illustrated.

The C. H. Wheeler Manufacturing Co., Philadelphia, Penn., has just issued its 1919 catalog containing 191 pages, and entitled "Condensers and Condensing." It contains 124 illustrations and a lot of useful information on different types of vacuum pumps, centrifugal pumps, direct-acting steam pumps, thermodynamics of condensers, jet and barometric condensers, surface condensers, water-cooling towers, economy of high vacuum, feed-water heaters, engines, marine equipment, etc., as well as tables on the properties of saturated steam from 32 to 212 deg. F., a relative humidity table, and one on mean barometric pressures corresponding to altitudes from 100 to 4900 ft. above sea level.

THE COAL MARKET

BOSTON—Current prices per gross ton f.o.b. New York loading ports:

Anthracite

	Company Coal
Egg	$7.80@7.95
Stove	7.95@8.15
Chestnut	8.05@8.35

Bituminous

	Clearfields	Cambrias and Somersets
F.o.b. mines, net tons	$2.15@2.75	$2.75@3.25
Philadelphia, gross tons	4.27@4.95	5.95@5.50
New York, gross tons	4.62@5.29	5.29@5.85
Alongside Boston (water coal), gross tons	6.10@6.85	6.90@7.55

Pocahontas and New River are quoted at $4.70@5.25 f.o.b. Norfolk and Newport News, Va., for spot coal, and $7.20@8.60 alongside Boston, these prices being on a gross ton basis.

NEW YORK—Current quotations, White Ash, per gross tons, f.o.b. Tidewater, at the lower ports are as follows:

	Mine	Company Circular		Mine	Company Circular
Broken	$6.05	$7.90	Pea	4.90	6.65
Egg	5.95	7.80	Buckwheat	3.40	5.15
Stove	6.20	8.05	Rice	2.75	4.50
Chestnut	6.30	8.15	Barley	2.25	4.00

Bituminous

	Spot	Contract
South Forks	$2.90 @ $3.25	$2.95 @ $3.50
Cambria County (good grades)	2.75 @ 2.95	2.95 @ 3.25
Clearfield County	2.50 @ 2.75	2.80 @ 2.95
Reynoldsville	2.50 @ 2.75	2.75 @ 2.95
Quemahoning	2.65 @ 2.85	2.95 @ 3.10
Somerset County (best grades)	2.65 @ 2.85	2.95 @ 3.10
Somerset County (poorer grades)	2.00 @ 2.35	2.50 @ 2.75
Western Maryland	2.25 @ 2.75	2.50 @ 2.75
Fairmont	2.00 @ 2.25	2.35 @ 2.50
Latrobe	2.10 @ 2.25	2.25 @ 2.40
Greensburg	2.25 @ 2.35	2.35 @ 2.60
Westmoreland	2.60 @ 2.75	2.60 @ 2.75
Westmoreland run-of-mine	2.35 @ 2.60	2.35 @ 2.65

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

PHILADELPHIA—The price per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide are as follows:

	Line	Tide		Line	Tide
Broken	$5.95	$7.80	Buckwheat	$3.40	$4.45
Egg	5.95	7.80	Rice	2.75	3.65
Stove	6.20	8.05	Boiler	2.50	3.50
Nut	6.30	8.15	Barley	2.25	3.15
Pea	4.90	6.50	Culm	1.25	2.15

CHICAGO—Current prices per ton for Illinois and Indiana coal are as follows:

Illinois

Williamson, Saline and Williamson Counties	Southern Illinois F.o.b. Mines	Northern Illinois F.o.b. Mines
Prepared sizes	$2.55@$2.75	$3.25
Mine-run	2.35@2.50	3.00
Screenings	1.85@2.20	2.75

BIRMINGHAM—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared	Slack and Screenings
Big seam	$2.45	$2.75	$2.40
Black Creek and Cahaba	3.45	3.75	3.05
Jagger - Pratt Corona	2.85	3.05	2.45
Blacksmith	....	5.25	.....

Domestic quoations, slightly increased, are as follows:

	Lump and Nut
Black Creek and Cahaba	3.85@$4.50
Corona	3.40
Jagger	3.50
Montvallo	5.00

ST. LOUIS—The prevailing circular per net ton f.o.b. mines is as follows:

	Mt. Olive and Staunton	Standard
Franklin County		
Prepared sizes, lump, egg, Nos. 1 and 2 nut	$2.75	.....
Williamson County		
Prepared sizes, lump, egg, nut	$2.55	$2.55	$2.00@2.25
Mine-run	2.35	2.20	1.60@1.75
Screenings	2.20	2.05	1.15@1.30
3-in. lump	....	2.30	
2-in. lump	....	....	1.75@1.90

Williamson-Franklin rate to St Louis is $1.07; other rates 92½c.

New Construction

PROPOSED WORK

Conn., Bridgeport—The Nichols Underwear Corp., James St. and Linen Ave., plans to build a 1-story, 26 x 26 ft. power plant in connection with the 2-story, 65 x 190 ft. factory which it plans to build on Benham Ave. Total estimated cost, $100,000. Fletcher-Thompson, Inc., 1089 Broad St., Engr.

Conn., Hartford—Libby, McNeil & Libby, 252 Asylum St., will soon award the contract for the construction of a 3-story, 50 x 112 ft. cold storage plant on Edwards St. Estimated cost, $60,000. P. Larmon, c/o Swift & Co., Union Stock Yards, Chicago, Ill., Engrs. Noted Feb. 4.

N. Y., New York—The Mt. Sinai Hospital, 100th St. and Madison Ave., will install a steam heating plant in the 2-story, 100 x 120 ft. auditorium which it plans to build on 99th St. east of 5th Ave. Total estimated cost, $150,000. A. W. Brunner, 101 Park Ave., arch.

Penn., Erie—The county will install a 1 and 2-story, 65 x 175 ft. power house in connection with the 2-story, 200 x 390 ft. home which it plans to build. Estimated cost, $200,000. Crooks & Cooley, Jones Law Bldg., Pittsburgh, Arch.

Penn., Mercer—The Elliott-Blair Steel Co., East Market St., is in the market for a 10 h.p., 3-phase, 220-volt motor. E. Elliott, Mgr.

Penn., Scranton—M. Maloney, Land Title Bldg., Philadelphia, will install a steam heating plant to heat the 32 houses which he plans to build on Adams Ave. Total estimated cost, $130,000. J. J. Howley, Traders Bank Bldg., Scranton, Arch.

Md., Baltimore—C. L. Reeder, Arch., 300 Park Ave., is receiving bids for installing new motors, electric lighting and wiring and electric elevators for the W. F. Assau Canning Co., Boston and Streeper St. Estimated cost, $10,000.

Fla., Sarasota—The City Council will receive bids until June 30 for the construction of a power plant, to include connecting pumps, wells, tower or reservoir, mains, hydrants, fittings and connections, etc. W. A. Ginn, Sanford, Consult. Engr.

Fla., Sarasota—The city will receive bids until June 9 for supplying equipment and material necessary for a water and electric lighting plant and system; to consist of 3 internal combustion fuel engines; two, 150 h.p. each; one 100 h.p., with D. C. generators, exciters to correspond to the given power; 2 rotary pumps, 1 right, 1 left, capacity 500 g.p.m. against 330 ft. head, D.C. to motors, equal to the lift with 25 p.c. overload, calculated as a factor of safety; 2 air compressors, 1 motor driven, 1 engine driven, single capacity equal to 100 cu.ft. per minute, pressure head 250 lbs. per sq. in., automatic cut-off; 2 air tanks, 4½ x 8 ft., double riveted, tested to 230 lbs. compression; gages, stop cocks, connections, air and water, some radiation to offices and connections for circulation 24 ft. above the engine base, to radiate from engine water jackets; file with bids 3 complete detail drawings showing base, longitudinal and transverse sections for base of all machines, all water, fuel lubricants, oil-action and connections, air and all connections, pumps, all centers (e ways) sections, discharge and foundation connections and switchboard. W. A. Ginn, Sanford, Consult. Engr.

S. C., Eau Clair (Columbia P. O.)—The Town Council plans election soon to vote on $40,000 bonds for the construction of a waterworks system to include pumping station, filters, etc. W. C. McCreight, Union National Bank Bldg., Columbia, Clk.

Ohio, Oxford—The Trustees of the Miami University will receive bids until June 14 for an engine and generator together with switchboard changes, wiring and piping connections, for the central heating and lighting plant. W. G. Franz, 1703 Union Trade Bldg., Cincinnati, Consult. Engr.

Ohio, Piqua—The French Oil Machinery Co. is having plans prepared by the J. J. Wernette Engineering Co., Engrs., 441 Houseman Bldg., Grand Rapids, Mich., for the construction of an addition to its power plant.

Ohio, Piqua—The Orr Felt & Blanket Co. is having plans prepared by the J. J. Wernette Engineering Co., Engrs., 441 Houseman Bldg., Grand Rapids, Mich., for the construction of a complete 84 x 150 ft., 1,000 h.p. plant.

Ohio, Sandusky—The Macultivator Co., Schmidt Apartments, will be in the market about July 15 for boilers, over 50 h.p.; conveyors, and belt for power plant; drilling machines, electric and hand; dynamos for power plant and lathes, etc. C. McCarthy, Gen. Mgr.

Ind., Crawfordville—The Standard Buick Co. is in the market for power plant machinery and pumps for power plant.

Mich., Detroit—The Board of Education, 50 B'way., will install a Plenum heating system and 1 boiler in the school which it plans to build on Georgia Ave. between Helen and Concord Ave., to be known as the Theodore Roosevelt School, also a Plenum heating system with 1 boiler in the 133 x 211 ft. standard design school No. 1088, which it plans to build on Georgia Ave. Malcomson & Higginbotham, 404 Moffat Bldg., Arch.

Mich., Detroit—The Oakman Boulevard Theatre Co., 9 Fort St., West, will install a heating plant, steam heating apparatus, motors and fans in the theatre, stores, etc., which it plans to build on Oakman Blvd. and Glendale Ave. Total estimated cost, $350,000. C. H. Crane and E. G. Kiehler, Dime Bank Bldg., Archts.

Mich., Detroit—The Liberty Motor Car Co., foot of Lycaste St., will install a 40 x 60 ft. heating plant, in connection with the plant which it plans to build on Charlevoix Ave. Austin & Co., 1954 Penobscot Bldg., Engr.

Mich., Detroit—St. Theresa Parish, c/o Van Leyen, Schilling & Keough, Arch., 1121 Union Trust Bldg., will install a steam heating plant in the 2-story, 70 x 180 ft. school which it plans to build on Grand River and Quincy Ave. Total estimated cost, $130,000.

Mich., Grand Rapids—The American Laundry Works, Division Ave., is having plans prepared by the J. J. Wernette Engineering Co., Engrs., 441 Houseman Bldg., for installing an engine and power plant.

Mich., Grand Rapids—The Nichols & Cox Lumber Co., 1069 Godfrey Ave., S. W., is in the market for a Union vacuum pump. W. Kemp, Ch. Engr.

Mich., Grand Rapids—The Regents Theatre Co., Woodward Ave., will install a steam heating plant and motors in the 2 story, 100 x 152 ft. theatre which it plans to build on Monroe Ave. Total estimated cost, $300,000. C. H. Crane and E. G. Kiehler, Dime Bank Bldg., Detroit, Arch.

Okla., Beggs—The Board of Trustees will receive bids until June 18 for installing a 7 x 8 ft. triplex pump and a 25 h.p. electric motor. W. K. Enoch, Town Clk.

Cal., Calexico—The city plans to install additional pumping facilities. Estimated cost, $20,000. P. B. Steintorff, City Clk.

Cal., California—The Bureau of Yards & Docks, Washington, D. C., plans to build a power plant at the Navy Coaling Yard, here. Estimated cost, $20,000.

Cal., Los Angeles—The Board of Public Service Commission, 645 South Oliver St., plan election soon to vote on $13,500,000 bonds, $2,500,000 to be used for constructing power plant No. 2 in San Francisquito canyon and power development in the Owens River Gorge, and $11,000,000 for purchasing the distributing system in Los Angeles owned by the Southern California Edison Co. E. F. Scattergood, 645 South Olive St., Engr.

Cal., Los Angeles—J. P. Vroman, secy. of the Board of Public Service Commission, wil receive bids until June 10 for furnishing valves and fittings for special penstock for power plant No. 2 in San Francisquito canyon. W. Mulholland, 645 South Olive St., Engr.

CONTRACTS AWARDED

Vt., Vernon—The Connecticut River Power Co., Osgood Bradley Bldg., Worcester, Mass., will build a 65 x 110 ft. addition to its power plant on the Connecticut River and install 2 additional electrical units of 5000 k.w. capacity. Total estimated cost, $1,000,000. Work will be done by day labor.

Mass., Boston—The Quincy Cold Storage Co. has awarded the contract for the construction of a 10-story, 60 x 180 ft. cold storage plant on the India Wharf, to the B. Fox, Inc., 15 Exchange St. Estimated cost, $500,000.

Conn., New Britain—Landers, Frary & Clark, Commercial St., has awarded the contract for the construction of a 14 x 23 ft. pump house and tank, to J. H. Grozier Co., 721 Main St., Hartford. Estimated cost, $14,000.

N. Y., Ogdensburg—The State Hospital Commission, Albany, received lowest three bids for boiler breeching at the St. Lawrence State Hospital, from Mansfield & Savage, 135 Williams St., New York City, $6,999; Murtagh & Reddington Co., 26 Pleasant St., Rochester, N. Y., $9,100; Austin Heating Co., 121 West 42nd St., New York City, $9,725. Noted Feb. 4.

N. Y., Syracuse—H. C. Allen, City Engr., received lowest three bids for installing heating and ventilating systems in Prescott School, from J. R. Sheehan Co., 16 South Center St., Schenectady, $43,213; W. B. Goldie, 274 James St., $45,915; E. Joy & Co., 133 Market St., $53,934.

Penn., Philadelphia—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing steam distributing systems at the Navy Yard here (work complete), from Almiral & Co., 1 Dominick St., New York City, $212,318; Lynch & Woodward, 287 Atlantic Ave., Boston, Mass., $262,576; H. E. Crook Co., 28 Light St., Baltimore, Md., $272,465. Specification No. 3876.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing 3 motor generator sets and switchboard at the Submarine Base here (work complete), from the General Electric Co., River Road, Schenectady, N. Y., $43,750; Westinghouse Electric & Manufacturing Co., 803 Hibbs Bldg., Washington, D. C., $47,133. Specification No. 3872.

Va., Hampton Roads—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing a high pressure air and water system at the Submarine Base here (work complete) from Almiral & Co., 1 Dominick St., New York City, $42,300; Noland Clifford Co., 330 28th St., Newport News, Va., $42,781; Newport Contracting & Engineering Co., Silsby Bldg., Newport News, Va., $46,175. Specification No. 3883. Noted May 20.

Wis., Sheboygan—Armour & Co., c/o A. Lotz, Chicago, has awarded the contract for the construction of a 1-story, 60 x 150 ft. cooler and warehouse on South Water St., to J. L. Carnegie, 189 West Madison St., Chicago, Ill. A cooling system will be installed in same. Total estimated cost, $55,000. Noted Apr. 15.

N. D., Devils Lake—R. E. Cobb Co., 3rd and Cedar St., St. Paul, Minn., has awarded the contract for the construction of a cold storage and meat plant, here, to H. C. Strucker, 405 Dakota Bldg., St. Paul, Minn. Estimated cost, $60,000.

Man., Winnipeg—The Department of Public Works, Ottawa, Ont., has awarded the contract for the construction of a 1-story, 110 x 122 ft. extension to the power house and laundry at the Military Hospital at Tuxedo, to Carter, Halls, Aldinger Co., 1010 Union Bank Bldg., Winnipeg. Estimated cost, $145,529. Noted Apr. 8.

P. I., Cavite—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received bids for installing power plant equipment for radio purposes, at the Naval Radio Station, here (1) net price and time for the entire work complete in accordance with the drawings and specifications, including traveling expenses of the supervising erector; (1a) net price per day for the services of supervising erector; (2) net price and time for 2 boilers to superheaters and accessories, fuel oil pumping equipment, and oil burning sets, flue and stack with supports, traveling expenses of the supervising erector for the above equipment; (2a) net price per day for the service of supervising erector; (3) net price and time for 2 turbo-alternators with accessories, 2 exciters sets, switchboard and equipment; traveling expenses of the supervising erector for above equipment; (3a) net price per day for service of a supervising erector; (4) net price and time for condensers with air ejectors and accessories, condensate pumps, cir. pumps, boiler feed pumps, traveling expenses of a supervising erector of the above equipment; (4a) net price per day for the services of supervising erector; (5) amount to be deducted from (4), if the services of a supervising erector are not required, from

Babcock & Wilcox Co., North American Building, Philadelphia, Penn., (2) $31,721, (2a) $12 per day; General Electric Co., River Road, Schenectady, N. Y., (3) $47,150, alternate $47,400; (3a) $20 per day; Westinghouse Electric & Manufacturing Co., Southern Bldg., Washington, D. C., (3) $47,366 (50 days); (3a) $25 per day; (4) $32,768, (150 days); (4a) $25 per day; (5) $1875. Specification No. 3871.

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Turn to pages 71 to 80

The SEARCHLIGHT SECTION of POWER is the "opportunity" centre of the power plant field. If you don't find what you want in this issue an advertisement in the next will probably get it for you.

PRICES - MATERIALS - SUPPLIES

These are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		70c. per ft.
Common, 2½-in.		40–10%

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.45	$0.30	$0.20

Steam—Discounts from List

First grade..... 35% Second grade..... 45% Third grade....50%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 65% Best grade..... 40%
Standard..... 50–10%

Note—Above discounts apply on new list issued July 1.

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	45%	35%
St. Louis	45%	50%
Chicago	45%	40%
Birmingham	35%	35%
Denver	35–5%	30%

RAWHIDE LACING—20% for cut; 45c. per sq. ft. for ordinary.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$0.90
Asbestos for high-pressure steam	1.60
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.60
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.20
Rubber sheet	.60
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.20
Asbestos wick, ½- and 1-lb. balls	85

PIPE AND BOILER COVERING—Below are discounts and part of standard lists:

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... List

For low-pressure heating and return lines { 4-ply..... 58% off; 3-ply..... 60% off; 2-ply..... 62% off

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	Cincinnati	Pittsburgh	Chicago	St. Louis	Birmingham	Denver
Cup	7	9	5½	7	8½	14½
Fiber or sponge	8	10	6	13	8½	18
Transmission	7	9	6	13	8½	20
Axle	4½	6	4	4.75	4	5½
Gear	4½	9	4½	7.5	8½	8
Car journal	22(gal.)	21(gal.)	3½	4.9	8½	8

COTTON WASTE—The following prices are in cents per pound:

	New York		Cleveland	Chicago
	Current	One Year Ago		
White	11.00 to 13.00	13.00	14.00	11.00 to 14.00
Colored mixed	8.50 to 12.00	12.00	11.00	9.50 to 12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13¼	13¼ x 20½
Cleveland	$52.00	$58.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York		Cleveland	Chicago		St. Louis
	Current	One Year Ago	Current	Current	One Year Ago	Current
Raw in barrels	$1.63	$1.55	$1.74	$1.78	$1.65	$1.69
5-gal. cans	1.76	1.65	1.90	1.98	1.75	1.75

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current Dry and In Oil	1 Yr. Ago Dry and In Oil
	Dry	In Oil	Dry	In Oil		
100-lb. keg	13.00	14.50	11.25	11.50	13.00	10.50
25- and 50-lb. kegs	13.25	14.75	11.50	11.75	13.25	10.75
12½-lb. keg	13.50	15.00	11.75	11.00	13.50	11.00
1-lb. cans	15.00	16.50	13.25	13.00	15.00	13.00
5-lb. cans	16.00	17.50	13.25	13.50	16.00	13.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

AMMONIA—Price per pound in St. Louis for 26 deg. U. S. P., 100-lb. car boys, is 11c.; in 1000-lb. drums, 9c.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	40%	60–5%	45%
Tinned	30%	60–5%	40%

Boiler rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:
New York....$6.35 Cleveland...$4.75 Chicago...$4.72 Pittsburgh... 4.65

Structual rivets, same sizes:
New York....$6.25 Cleveland...$4.85 Chicago...$4.82 Pittsburgh...$4.75

REFRACTORIES—Following prices are f. o. b. works, Pittsburgh:

Chrome brick	net ton	$120.00 at Chester, Penn.
Chrome cement	net ton	65.00 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48 at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90 at Chester, Penn.
Silica brick	net ton	45–55 at Mt. Union, Penn.

Standard size fire brick, 9 x 4½ x 2½ in. The second quality is $4 to $5 cheaper per 1000.

St. Louis—Fire Clay, $35 to $50.
Birmingham—Fire clay, $41–$44; silica, $46, $50–$15.50 magnesite, $80–$85; chrome, $80–$90.
Chicago—Second quality, $25 per ton.
Denver—Silica, $35 per 1000.

FUEL OIL—Domestic light, 22-26 deg., Baume, is 10½c. per gal. in St. Louis

BABBITT METAL—Warehouse prices in cents per pound:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Best grade	87.00	90.00	79.00	90.00	75.00	90.00
Commercial	42.00	50.00	18.50	30.00	15.00	30.00

SWEDISH (NORWAY) IRON—The average price per 100 lb., in ton lots, is:

	Current	One Year Ago
New York	$25.50–30	$15.00
Cleveland	20.00	15.00
Chicago	16.50	15.00

In coils an advance of 50c. usually is charged.
Domestic iron (Swedish analysis) is selling at 15c. per lb.

POLES—Prices on Western red cedar poles:

	New York	Chicago	Denver	San Francisco
6 in. by 30 ft.	$5.82	$5.17	$4.55	$5.17
7 in. by 30 ft.	7.65	6.85	6.10	6.85
7 in. by 35 ft.	11.10	10.00	8.95	10.00
8 in. by 35 ft.	12.65	11.35	10.10	11.35
7 in. by 40 ft.	12.85	11.50	10.20	11.50
8 in. by 45 ft.	18.90	16.90	15.00	16.90
8 in. by 50 ft.	22.65	20.30	18.00	20.30

10c. higher freight rates on account of double loads.
For plain pine poles, delivered New York, the price is as follows:

10-in. butts, 5-in. tops, length 20-30 ft.	$9.00
12-in. butts, 6-in. tops, length 30-40 ft.	11.50
12-in. butts, 6-in. tops, length 41-50 ft.	12.50
14-in. butts, 6-in. tops, length 51-60 ft.	21.00
14-in. butts, 6-in. tops, length 61-71 ft.	23.50

PIPE—The following discounts are for carload lots f. o. b. Pittsburgh; basing card of Jan. 1, 1919, for steel pipe and for iron pipe:

BUTT WELD

Inches	Steel Black	Steel Galvanized	Inches	Iron Black	Iron Galvanized
⅛, ¼ and ⅜	50½%	24%	⅜ to 1¼	39½%	23½%
½	54½%	40%			
¾ to 3	57½%	44%			

LAP WELD

2	50½%	38%	2	32½%	18½%
2½ to 6	53½%	41%	2½ to 6	34½%	21½%

BUTT WELD, EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	46½%	29%	½ to 1¼	39½%	24½%
½	51½%	39%			
¾ to 1¼	55½%	43%			

LAP WELD, EXTRA STRONG PLAIN ENDS

2	48%	37½%	2	33½%	20½%
2½ to 4	51%	40½%	2½ to 4	35½%	23½%
4½ to 6	50%	39¼%	4½ to 6	34½%	22½%

Stock discounts in cities named are as follows:

	New York Black	New York Galvanized	Cleveland Black	Cleveland Galvanized	Chicago Black	Chicago Galvanized
⅜ to 3 in. steel butt welded	47%	31%	46½%	31%	57½%	44%
2½ to 3 in. steel lap welded	42%	27%	42½%	27½%	51½%	41%

Malleable fittings. Class B and C, from New York stock sell at list + 12½%.
Cast iron, standard sizes, 10% off.

BOILER TUBES—The following are the prices for carload lots, f. o. b Pittsburgh:

Lap Welded Steel		Charcoal Iron	
3½ to 4½ in.	40½	3½ to 4½ in.	15½
2½ to 3¼ in.	30½	3 to 3¼ in.	1
2¼ in.	24	2½ to 2¾ in.	+ 1
1¾ to 2 in.	19½	2 to 2¼ in.	+16
		1¼ to 1¾ in.	+29

Standard Commercial Seamless—Cold Drawn or Hot Rolled

	Per Net Ton		Per Net Ton
1 in.	$327	1¾ in.	$207
1¼ in.	267	2 to 2½ in.	177
1½ in.	257	2¾ to 3¼ in.	167
1½ in.	207	4 in.	187
		4½ to 5 in.	207

These prices do not apply to special specifications for locomotive tubes nor to special specifications for tubes for the Navy Department, which will be subject to special negotiation.

ELECTRICAL SUPPLIES

General Decline Expected, To Be Noted in Next Issue

ARMORED CABLE—

B.&S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$104.00	$138.00	$164.00	$222.00
No. 12 solid	135.00	170.00	211.00	290.00
No. 10 solid	185.00	235.00	255.00	325.00
No. 8 stranded	235.00	325.00	345.00	450.00
No. 6 stranded	370.00	472.00	625.00	.....

From the above lists discounts are:

	Net List
Less than coil lots	
Coils to 1,000 ft.	10%
1,000 ft. and over	15%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever Ready

	Each, Net
Less than 12	$0.40
12 to 50	.38
50 to 125 (bbl.)	.35
125 (bbl.) or over	.32

CONDUITS, ELBOWS AND COUPLINGS—Following are warehouse net prices per 1000 ft. for conduit and per 100 for couplings and elbows:

	Conduit		Elbows		Couplings	
Size, In.	Black 1,000 Ft. and Over	Galvanized 1,000 Ft. and Over	Black 100 and Over	Galvanized 100 and Over	Black 100 and Over	Galvanized 100 and Over
⅜	$71.15	$76.25	$17.04	$18.18	$5.38	$5.74
½	71.15	76.25	17.04	18.18	6.28	6.70
¾	93.96	100.86	22.43	23.93	8.97	9.57
1	138.39	149.09	33.19	35.41	11.66	12.44
1¼	187.91	201.71	42.62	45.31	16.10	17.12
1½	224.68	241.18	56.82	60.62	19.89	21.15
2	302.29	324.49	104.17	110.77	26.52	28.20
2½	477.95	513.05	170.46	181.26	37.88	40.28
3	625.00	670.91	454.56	483.36	56.82	60.42
3½	779.24	834.44	1,003.82	1,067.42	75.76	80.56
4	945.03	1,010.43	1,160.08	1,233.57	94.70	100.70

5% cash 10 days.

From New York Warehouse—Less 5% cash.

Standard lengths rigid, 10 ft. Standard lengths flexible, ¾ in., 100 ft. Standard lengths flexible, ⅜ to 2 in., 50 ft.

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.	
⅜	250	$0.05½	
½	250	.06	
⅝	250	.09	
¾	200	.12	
⅞	200	.15	Coils....60% off
1	150	.18	Less coils, 50% off
1	100	.25	
1¼	100	.33	
1½	Odd lengths	.40	
2	Odd lengths	.55	

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.11	T. P. to D. P. S. B.	$0.24
D. P. M. L.	.18	T. P. to D. P. T. B.	.38
T. P. M. L.	.26	T. P. S. B.	.33
D. P. S. B.	.19	T. P. D. B.	.54
D. P. D. B.	.37		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.33	$0.84	$1.68
T. P. M. L.	.48	1.20	2.40
D. P. S. B.	.42	1.05	.....
T. P. S. B.	.81	1.80	.....
D. P. D. B.	.78	2.10	.....
T. P. D. B.	1.35	3.60	.....
T. P. to D. P. D. B.	.90	2.52	.....

FLEXIBLE CORD—Price per 1000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$18.00
No. 16 cotton twisted	24.00
No. 18 cotton parallel	25.00
No. 16 cotton parallel	32.00
No. 18 cotton reinforced heavy	35.00
No. 16 cotton reinforced heavy	42.00
No. 18 cotton reinforced light	30.00
No. 16 cotton reinforced light	36.00
No. 18 cotton Canvasite cord	29.00
No. 16 cotton Canvasite cord	35.00

FUSES, ENCLOSED—

250-Volt	Std. Pkg	List
3-amp. to 30-amp.	100	$0.25
35-amp. to 60-amp.	100	.35
65-amp. to 100-amp.	50	.90
110-amp. to 200-amp.	25	2.00
225-amp. to 400-amp.	25	3.60
2-amp. to 600-amp.	10	5.50

600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	.40
35-amp. to 60-amp.	100	.60
65-amp. to 100-amp.	50	1.50
110-amp. to 200-amp.	25	2.50
225-amp. to 400-amp.	25	5.50
450-amp. to 600-amp.	10	8.00
Discount: Less 1-5th standard package	30%	
1-5th to standard package	40%	
Standard package	52%	

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.75 C
0-30 ampere, less than standard package	6.00 C

LAMPS—Below are present quotations in less than standard package quantities.

Straight-Side Bulbs				Pear-Shape Bulbs			
Mazda B— Watts	Plain	Frosted	No. in Package	Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.38	100	75	$0.70	$0.75	50
15	.35	.38	100	100	1.10	1.15	24
25	.35	.38	100	150	1.65	1.70	24
40	.35	.38	100	200	2.20	2.27	24
50	.35	.38	100	300	3.25	3.35	24
60	.40	.45	100	400	4.30	4.45	12
100	.85	.92	24	500	4.70	4.85	12
				750	6.50	6.75	8
				1000	7.50	7.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Hubbell, porcelain No. 5406, standard package 250	$0.24
Hubbell composition No. 5467, standard package 50	.32
Benjamin swivel No. 903, standard package 250	.20
Hubbell current taps No. 5638, standard package 50	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. in New York

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$12.00	$14.00	$13.90	$25.00
12	13.25	15.70	18.05	30.70
10	18.30	21.00	23.85	41.50
8	25.54	28.60	32.70	56.77
6	.....	.....	51.40	.....
4	.....	.....	70.00	.....
2	.....	.....	101.80	.....
1	.....	.....	131.86	.....
0	.....	.....	160.00	.....
00	.....	.....	193.50	.....
000	.....	.....	235.20	.....
0000	.....	.....	288.60	.....

Prices per 1000 ft. for Rubber-covered Wire in Following Cities:

	Denver			St. Louis			Birmingham		
No.	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex	Single Braid	Double Braid	Duplex
14	$11.00	$14.50	$30.40	$16.00	$21.00	$33.00	$9.92	$15.25	$27.75
10	19.20	25.70	49.00	27.20	31.00	69.00	20.25	24.25	46.90
8	26.95	34.25	67.00	38.00	42.00	78.00	27.60	32.60	.....
6	43.90	46.20	.....	.....	65.00	130.00	48.25	54.75	.....
4	62.35	65.15	.....	.....	93.00	.....	66.90	73.75	.....
2	92.60	96.25	.....	.....	140.00	.....	96.00	104.50	.....
1	120.95	125.20	.....	.....	182.00	.....	121.00	136.40	.....
0	164.80	164.80	.....	.....	242.00	.....	169.00	174.60	.....
00	.....	203.35	.....	.....	290.00	.....	203.50	214.00	.....
000	.....	248.40	.....	.....	360.00	.....	246.00	257.50	.....
0000	.....	302.55	.....	.....	435.00	.....	295.50	308.50	.....

Pittsburg—34c. base; discount 50%

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap.				¾ In. Cap	
Key, Each	Keyless, Each	Pull, Each	Key, Each	Keyless, Each	Pull, Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+20%
1-5th to standard package	+10%
Standard package	−15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B.&S. regular spools (approx. 8 lb.)	36c. lb.
No. 18 B.&S. regular 1-lb. coils	37c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	48c. lb.
Rubber tape, ¾ in., less 100 lb., 65c. lb., 100 lb. lots	60c. lb.
Wire solder, less 100 lb. 50c. lb., 100 lb. lots	46c. lb.
Soldering paste, 2 oz. cans Nokorode	$1.20 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	.70	1.06	1.60	2.120
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.3
200	4.40	6.76	10 14	13.50

Discounts:

Less than $10.00 list value	+ 5%
$10 to $25 list value	— 8%
$25 to $50 list value	—15%
$50 to $200 list value	—20%
$200 list value or over	—25%